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FINAL

**Bioventing Pilot Test Work Plan for
Site ST200 (SA38)**



**MCCELLAN AIR FORCE BASE
CALIFORNIA**

Prepared for

**Air Force Center For Environmental Excellence
Brooks Air Force Base, Texas**

and

**Environmental Management
McClellan Air Force Base, California**

June 1997

Prepared by

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FINAL

**BIOVENTING PILOT TEST WORK PLAN
FOR SITE ST200 (SA38)**

at

McCLELLAN AIR FORCE BASE, CALIFORNIA

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SECTION 1

INTRODUCTION

1.1 SCOPE AND OBJECTIVES

This Bioventing Pilot Test Work Plan presents the scope of an *in situ* bioventing pilot test and installation of a bioventing system for treatment of petroleum hydrocarbon-contaminated soils at Site ST200 at McClellan Air Force Base (AFB), Sacramento County, California. The primary goal of the bioventing system is to remove the potential source of groundwater contamination from the soil. The system is not designed to reduce contaminant concentrations in groundwater. Four main objectives toward achieving the goal of removing contaminants from the soil are: 1) assess the potential for supplying oxygen throughout the petroleum hydrocarbon-contaminated soil zone, 2) determine the rate at which indigenous microorganisms will degrade the contaminants in the soil when stimulated by oxygen-rich soil vapor, 3) evaluate the potential for sustaining these rates of fuel biodegradation, and 4) gather baseline data which can be used in the future to evaluate the effectiveness of bioventing in treating site soils.

The bioventing pilot test will determine the technical feasibility of bioventing at this site and establish important design parameters such as air permeability, radius of influence, and fuel biodegradation rates. A significant amount of the contamination should be biodegraded during the pilot test since bioventing will take place within the most contaminated soils.

Additional background information on the development and success of the bioventing technology is found in the document entitled *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing* (Hinchee et al., 1992) and *Principles and Practices of Bioventing* (Leeson and Hinchee, 1995). These protocol documents will serve as the primary references for the pilot test well designs and detailed procedures which will be used during the test. In addition, a General Engineering Evaluation/Cost Analysis (EE/CA) document in support of using bioventing as a presumptive remedy has also been prepared (Stanin et al., 1996).

Much of the background information used in this Bioventing Pilot Test Work Plan is derived from prior studies and reports, which are listed in Section 7.

1.2 HISTORICAL SUMMARY OF BIOVENTING AT MCCLELLAN AFB

Bioventing has been implemented by Parsons Engineering Science, Inc. (Parsons ES) at six other McClellan AFB sites: Tank Farm #2, Tank Farm #4, SA6, PRL T-46, Davis Global Communications, and Capehart Gas Station (Engineering-Science, Inc. [ES], 1994; AFCEE,

1995; Parsons ES, 1996a). Data from each of these sites has demonstrated the effectiveness of bioventing as a remediation alternative for petroleum hydrocarbon-contaminated soils at McClellan AFB.

Based on initial air permeability and respiration testing, biodegradation rates of 40 to 2,500 mg of fuel per kilogram of soil per year and a typical radius of influence of 30 to 50 feet were estimated for these sites. Each site was resampled after one year of operation of each bioventing system and residual hydrocarbon concentrations generally were reduced by an order of magnitude or more, especially concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX) (AFCEE, 1995). At Tank Farm #4, residual concentrations of fuel hydrocarbons in soil have been reduced to non-detect concentrations and concurrence has been received from the lead regulatory agency for No Further Investigation (NFI) Status (CRWQCB, 1997).

1.3 REPORT ORGANIZATION

This Work Plan consists of seven sections, including this introduction. Section 2 includes a site description, history, and summary of previous investigation activities and analytical results. Section 3 discusses proposed site activities including installation of the bioventing system, system tests and monitoring, soil and soil vapor sampling, and quality assurance/quality control procedures. Section 4 discusses Base support requirements. Sections 5 and 6 provide the proposed project schedule and points of contact. References used for preparation of this report are provided in Section 7. Appendix A contains copies of available ST200 boring logs.

SECTION 2

SITE DESCRIPTION AND HISTORY

2.1 SITE LOCATION AND HISTORY

2.1.1 McClellan AFB

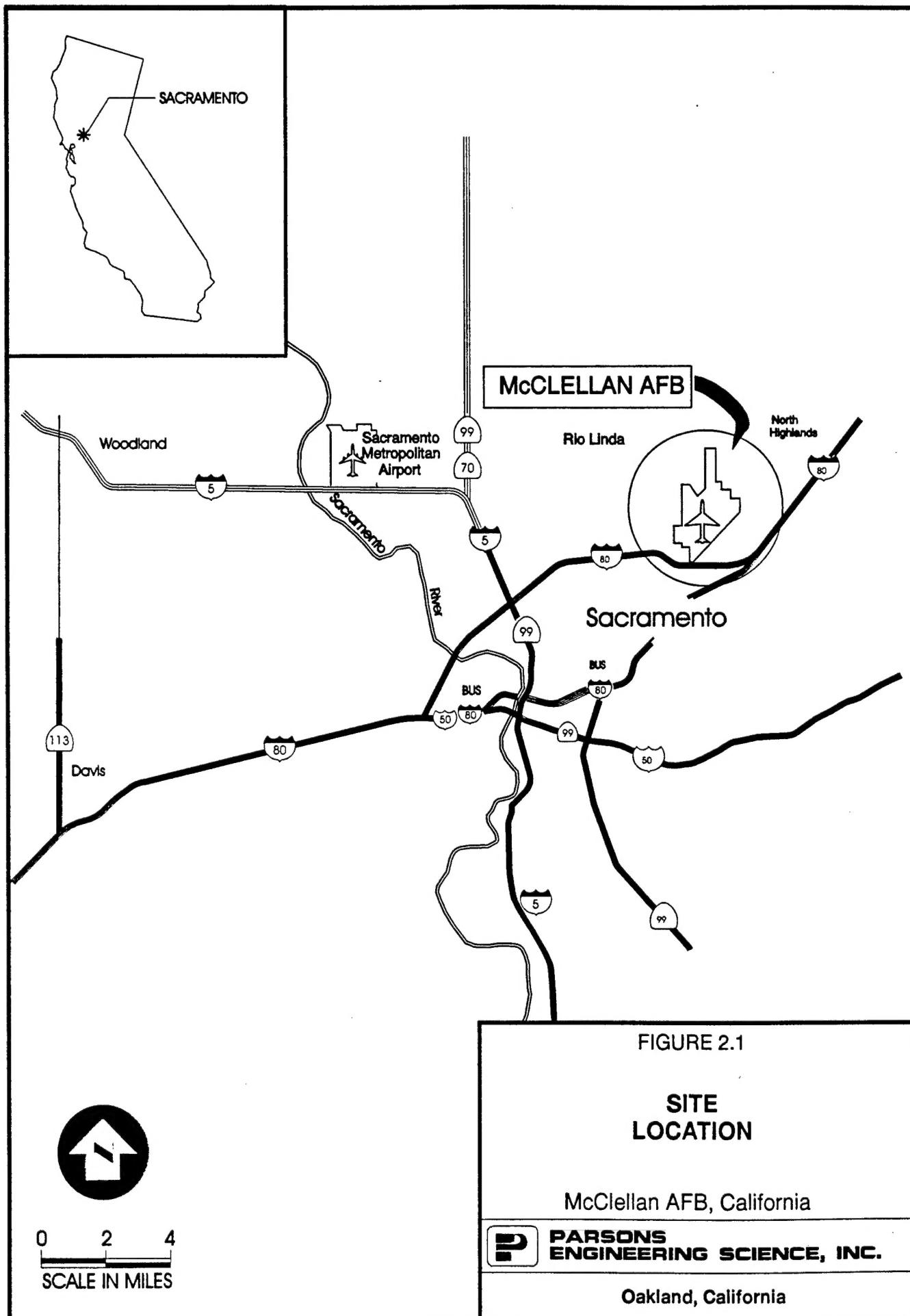
McClellan AFB, an Air Force Logistics Center, is located approximately 7 miles northeast of downtown Sacramento and covers approximately 3,000 acres (Figure 2.1). Employing approximately 15,000 civilian and military personnel, the base provides worldwide logistics support for weapons systems, equipment, and commodity items as well as maintenance, supply, and contracting services. The base was established in 1936 and since that time has managed, maintained, and repaired various aircraft, electronics equipment, and communications equipment. These operations have generated various hazardous and toxic wastes, including: industrial solvents, electroplating wastes, heavy metals, PCB contaminated oils, jet fuels, and a variety of oils and lubricants.

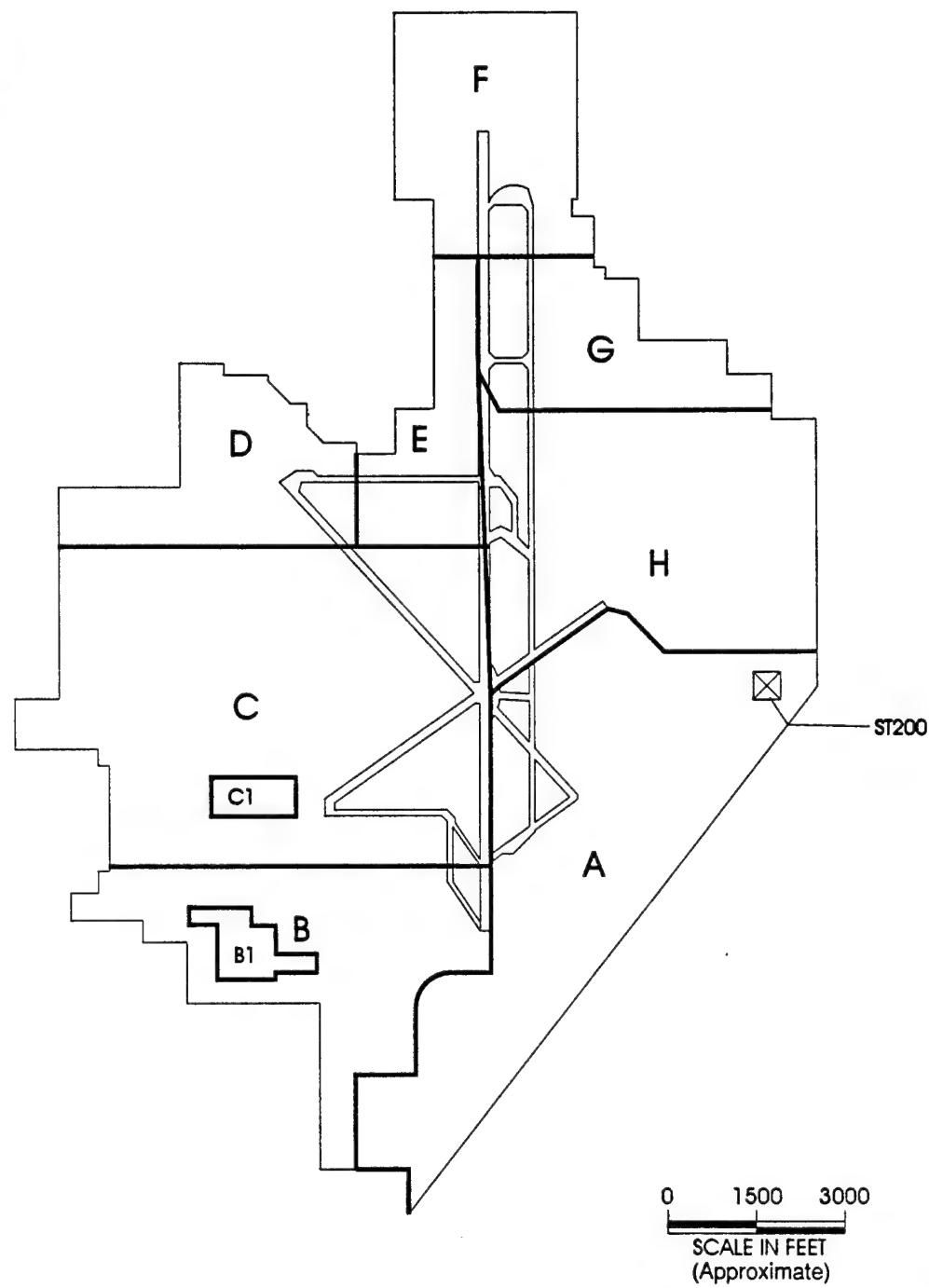
Hazardous wastes were disposed of at a variety of burial pits, sludge pits, and miscellaneous disposal trenches and pits. In 1979, groundwater contamination was discovered and subsequently base production wells were shut down. Since that time, base production wells have been retrofitted with well head treatment systems, numerous monitoring wells have been installed, and three groundwater extraction systems have been installed to prevent migration of contaminants. A groundwater treatment plant was constructed in 1985.

Numerous environmental investigations have been performed throughout McClellan AFB as part of the U. S. Air Force (USAF) Installation Restoration Program (IRP) and an Interagency Agreement (IAG) between state and federal agencies. Possible sources of contamination at McClellan AFB identified in prior studies are grouped by geographic area, designated as Operable Units (OU) A through H (Figure 2.2). Each OU was further broken down into geographic investigation clusters (IC) comprised of multiple sites. An additional OU separately addresses groundwater contamination. ST200, also known as SA38, is located within IC25 in OU A (Figure 2.2).

2.1.2 ST200

ST200 is located on the east side of the Base and covers approximately one acre (Figure 2.3). The site is comprised of a former automobile service station building (Building 26) and associated landscaping. ST200 is bounded by Arnold Avenue to the east, an asphalt-paved driveway and parking lot to the north and west, and Building 24 to the south. Building 24





0 1500 3000
SCALE IN FEET
(Approximate)

FIGURE 2.2

**APPROXIMATE BOUNDARIES
OF OPERABLE UNITS AND
LOCATION OF ST200**

McClellan AFB, California



**PARSONS
ENGINEERING SCIENCE, INC.**

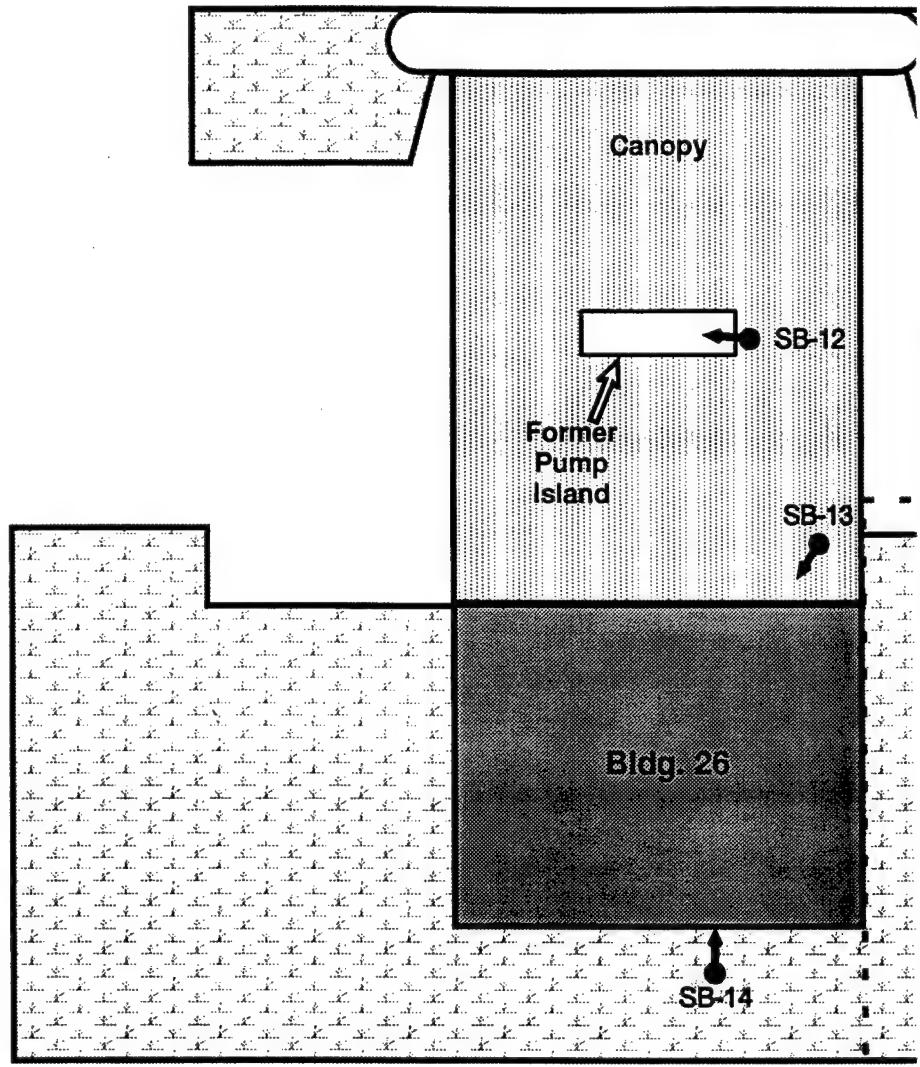
Oakland, California

EXPLANATION
— BOUNDARIES OF OPERABLE UNITS
— McCLELLAN AFB BOUNDARY

Driveway

Legend

-  Groundwater Monitoring Well
-  SB-2 Approximate Location of Previous Boring
-  SB-14 Approximate Location of Previous Slant Boring
-  Fire Hydrant
-  Tree
-  Lawn
-  Planter Area
-  Canopy
-  Building

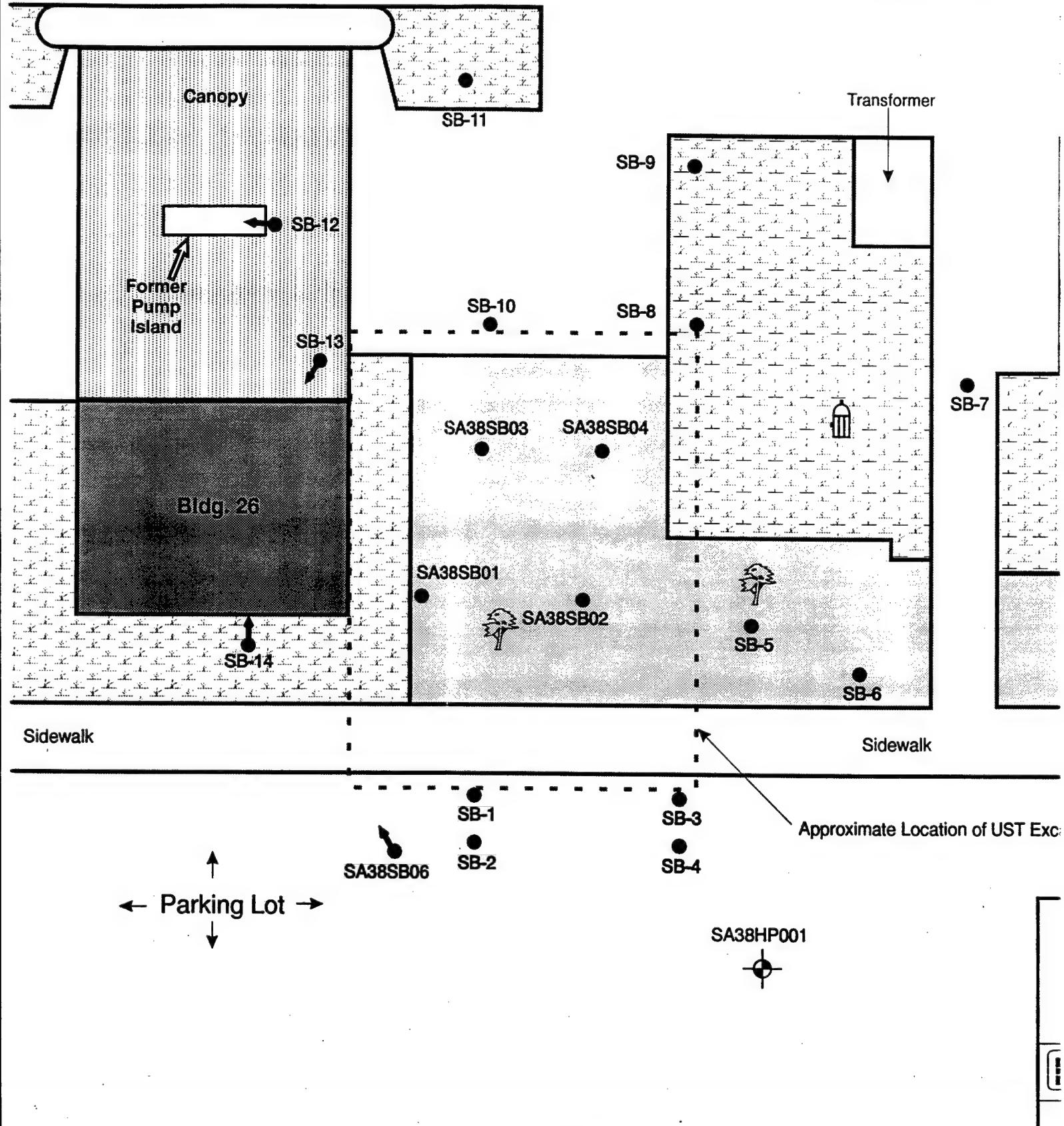


Sidewalk



0 5 10
SCALE IN FEET
(Approximate)

Arnold Avenue



ue

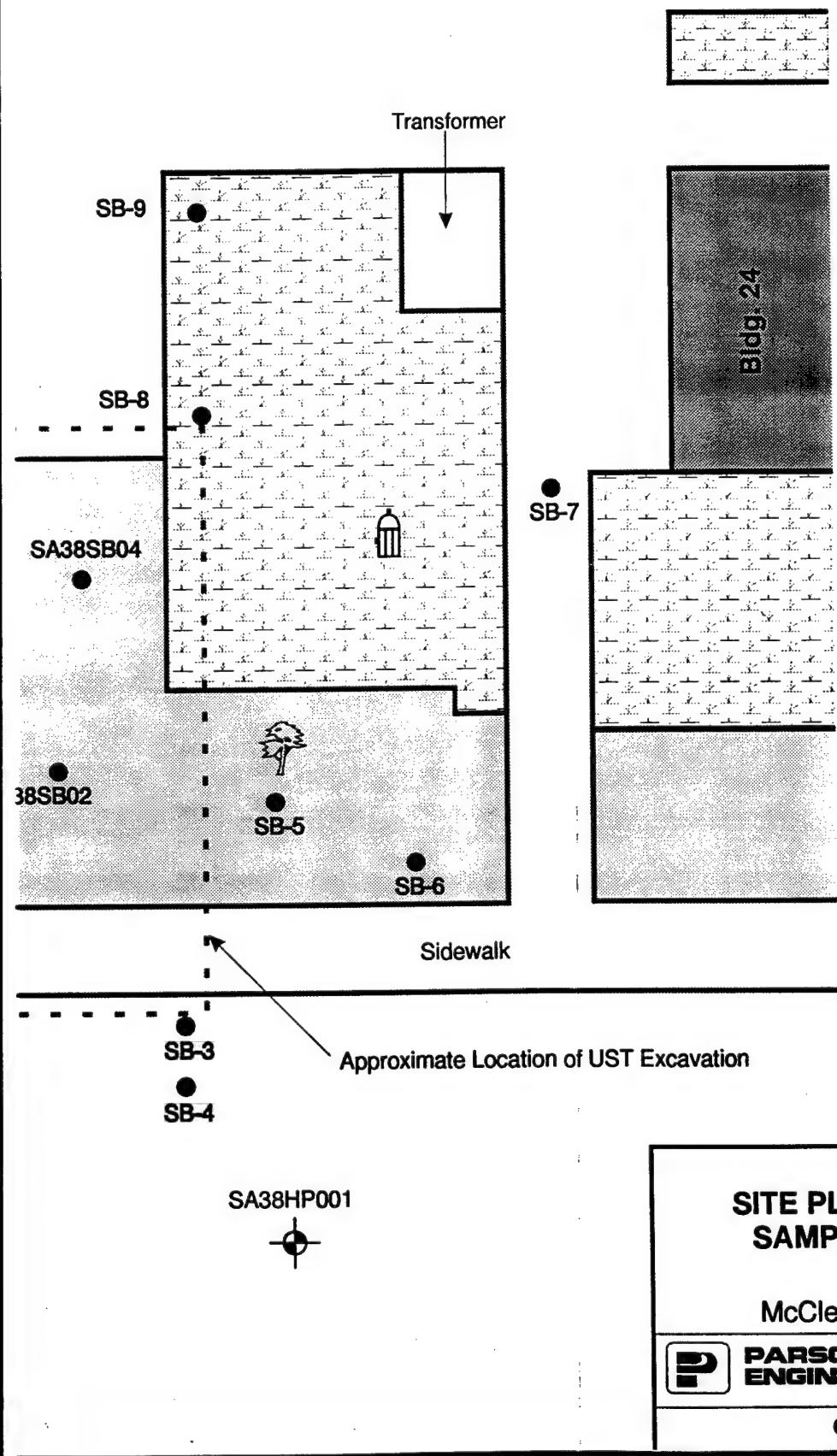


FIGURE 2.3
**SITE PLAN and PREVIOUS
SAMPLING LOCATIONS
SITE ST200**
McClellan AFB, California

 **PARSONS
ENGINEERING SCIENCE, INC.**

Oakland, California

currently houses various administrative departments, but was a motor pool from 1939 to 1972. Both Building 24 and Building 26 were built using concrete slab-on-grade construction. Building 26 and the surrounding areas have been designated for preservation as a historic site.

The automobile service station (Building 26) operated from 1940 to approximately 1990 (Jacobs Engineering Group [JEG], 1995). From 1940 to 1980 fuel was stored in two 5,000-gallon underground storage tanks (USTs). In 1980 these USTs were removed and replaced with one 5,000-gallon diesel UST and one 10,000-gallon unleaded gasoline UST. The USTs were located adjacent to the south side of Building 26 and the fuel island was located between the east side of Building 26 and Arnold Avenue. During precision leak tests in 1987, both USTs were found to be leaking at the gaskets that joined the manways (AEMC, 1987). After replacing the manway gaskets, the USTs tested "tight". The tanks and associated piping and pumps were removed in November 1990. During removal of the USTs, soil contamination was observed in the excavation pit and beneath Building 26.

2.2 GEOLOGY AND HYDROGEOLOGY

2.2.1 McClellan AFB Geology and Hydrogeology

McClellan AFB is situated within the Sacramento Valley, a deep trough of sediments primarily derived from weathering of the Sierra Nevada mountains and transported by numerous tributaries to the meandering Sacramento River. The valley is covered by alluvial and fluvial deposits, which were frequently eroded and redeposited by local streams. Meandering and abandonment of stream channels has produced complex regional as well as local stratigraphy dominated by lenses of material with little lateral or vertical continuity. Regionally, soils are mostly fine-grained, but approximately 25 to 30 percent of the deposits are sand and gravel. Soils in the vicinity of the base are extremely variable, but are generally classified as fine, sandy loams. These soils have low shrink-swell potential and generally low soil permeabilities, varying locally.

The alternating layers of channels, overbank deposits, backwater deposits, sand bars, and widespread flood deposits today form an aquifer system that is extremely variable over short distances, but broadly interconnected. This aquifer system has been separated into a series of zones for purposes of groundwater monitoring, and are designated A through E, from shallowest to deepest. Within OU A, the water table is typically between 100 and 125 feet below ground surface (bgs) (JEG, 1995). Within the last ten years, the water table has been steadily declining at a rate between 1.25 and 2.0 feet per year due to over drafting by irrigation, supply, and extraction wells.

A contaminant smear zone of residual liquid and gaseous phase contaminants (primarily chlorinated aliphatic hydrocarbons) exists in the lower vadose zone at contaminated sites throughout McClellan AFB due to changes in flow direction and the declining water table (JEG, 1995). As groundwater levels declined, contaminants have re-partitioned to the vadose zone as gases and some contaminants have remained adsorbed onto soil particles.

The aquifer zones are not hydraulically independent and groundwater can flow vertically between them. Horizontal groundwater movement in each zone is generally in a south-southwest direction, toward a regional pumping depression south of Sacramento. South and west of McClellan AFB numerous active private and public water supply wells influence the immediate subregional groundwater flow; therefore, groundwater flow directions on the base are dependent on location. The groundwater extraction systems installed at McClellan AFB during the 1980s also exert some local hydraulic control in the shallow aquifer zones.

2.2.2 ST200 Geology and Hydrogeology

Site geology has been interpreted from borings SA38SB01 through SA38SB04 and SB38SB06, which were advanced at ST200 during the Basewide Remedial Investigation (RI) conducted in 1993 and in 1996 (JEG, 1995; JEG, 1996). The total depth of these borings ranged from 95.5 to 97 feet below ground surface (bgs). Figure 2.3 shows the previous sampling locations and Appendix A contains copies of the boring logs.

Site soils are typical of the fluvial deposits found throughout OU A and consist of primarily heterogeneous and discontinuous layers of silt and fine sand. The typical subsurface profile within the former UST excavation at ST200 is characterized by gravel fill (excavation backfill) in the upper 14 feet and interbeds of primarily silt and fine sand between 14 and 97 feet below ground surface (bgs). Outside of the former UST excavation the upper 14 feet of soil also consists of sand and silt interbeds. At 50 feet bgs, an approximately 15-foot thick sand zone is encountered which extends throughout IC25.

Groundwater is encountered at approximately 110 feet bgs beneath IC25 and is expected to flow west/southwest (JEG, 1995). Sample location SA38HP001 was converted to a groundwater monitoring well or piezometer in late 1996, but groundwater level data was not available by the date of this Work Plan.

Hydraulic testing was performed on A-zone monitoring well MW-210, located approximately 350 feet northwest of the ST200 (Radian, 1992). The hydraulic conductivity was estimated to be 2 ft/day with a seepage velocity of 0.03 ft/day (11 ft/year), reflecting the relatively low permeability and flat hydraulic gradient of the A-monitoring zone near ST200.

2.3 PREVIOUS INVESTIGATIONS AT ST200

2.3.1 UST Removal and Initial Site Investigations

During tank removal operations in November 1990 three soil samples (A-South, B-South, and C-North) were taken from the bottom of the excavation pit, at approximately 11 feet bgs (County of Sacramento, 1990). Exact locations for the samples were not available and, therefore, are not shown on Figure 2.3. Soil samples were analyzed for total petroleum hydrocarbons (TPH), total recoverable petroleum hydrocarbons (TRPH), purgeable aromatics including benzene, toluene, ethylbenzene, and total xylenes (BTEX), halogenated volatile organic compounds (VOCs), and metals. No halogenated VOCs were detected.

The analytical results for TPH and BTEX are listed in Table 2.1. All three samples contained detectable concentrations of petroleum hydrocarbons except benzene. Benzene was not

detected in any of the three samples. The maximum detected concentrations were: 2,400 mg/kg TPH as gasoline (TPH-g), 5,950 mg/kg TPH as diesel (TPH-d), 367 mg/kg TPH as motor oil (TPH-mo), 9,310 mg/kg TRPH, 0.120 mg/kg toluene, 0.474 mg/kg ethylbenzene, and 9.46 mg/kg total xylenes. The maximum concentrations of TPH-g, TPH-mo, and the BTEX components were detected in sample A-South. The maximum concentrations of TPH-d and TRPH were detected in sample C-North (presumably located nearest Building 26). During removal operations, soil contamination appeared to extend beneath Building 26. The analytical laboratory reported that the fuel pattern for samples with detectable concentrations of TPH-g did not match their gasoline standard. This notation and the relatively low BTEX concentrations compared to TPH-g concentrations suggests some degree of weathering has occurred.

In March 1991, 14 borings (SB-1 through SB-14) were advanced to depths of 10 to 20 feet in and around the UST excavation pit (Figure 2.3). Soil samples were collected from some of the borings and analyzed for TPH and organic lead (Table 2.1). TPH-g and TPH-d were detected in borings SB-12, SB-13, and SB-14. SB-13 and SB-14 were slant borings (40° from vertical) advanced beneath or very close to Building 26. SB-12 was a slant boring advanced beneath the former pump island. Maximum concentrations of 6,410 mg/kg TPH-g, 3,060 mg/kg TPH-d, and 0.07 mg/kg organic lead were detected in boring SB-13 at a depth of 2 feet.

In May 1991, the UST excavation was enlarged until the sidewalls were flush with borings SB-1, SB-3, SB-8, and SB-10 and the base was at 13 feet bgs (Figure 2.3). Prior to backfilling, soil samples A-13, B-13, C-13, and D-13 (locations not reported) were collected from the base of the excavation and analyzed for TPH (Table 2.1). Maximum concentrations of 1,850 mg/kg TPH-g and 621 mg/kg TPH-d were detected in the floor of the excavation.

2.3.2 Phase I Remedial Investigation

The Phase I RI at OU A was conducted between 1992 to 1995 (JEG, 1995). During the RI investigation, four borings were advanced to a depth of 97 feet bgs through the former UST excavation at ST200. Soil and soil vapor samples were collected from the 4 borings, designated SA38SB01 through SA38SB04 (Figure 2.3). Soil samples were collected from depths of approximately 15, 20, 30, 40, 60, 80, and 95 feet bgs for TPH, BTEX, organic lead, and moisture analysis. Downhole soil vapor samples were collected from depths of approximately 12, 22, 42, 62, 82, and 97 feet bgs and analyzed for aromatic and halogenated VOCs. The soil and soil vapor samples analytical results are presented in Tables 2.2 through 2.5.

Residual soil contaminants were primarily concentrated between approximately 15 and 30 feet bgs in the four borings (Table 2.2). The maximum TPH-g concentration (5,900 mg/kg) and maximum total BTEX concentration (203 mg/kg) were detected in SA38SB01 at a depth of 15 feet bgs. The maximum TPH-d concentration of 780 mg/kg was detected in boring SA38SB03 at a depth of 15 feet bgs. Benzene (0.011 mg/kg) was only detected in boring SA38SB02 at a depth of 30 feet bgs. Moisture content was measured between 4.6 and 34 percent by weight, with more than 72% of the samples greater than or equal to 15 percent moisture content.

Table 2.1
Soil Analytical Results for Petroleum Hydrocarbons
UST Excavation Pit Samples & Shallow Soil Borings, Site ST200
McClellan AFB, California

Sample Date	Contractor	Sample No.	Depth (bgs)	Total Petroleum Hydrocarbons			Purgeable Aromatics				
				Method:	8015 (Mod.)		418.1	8020		Ethyl-benzene	
					TPH-g	TPH-d	TPH-mo	TRPH	Benzene		
Nov-90	McClellan	A-South	11	2,400	1,070	367	2,060	<0.025	0.120	0.474	9.46
		B-South	11	593	<10	<25	75	<0.005	0.006	0.087	0.612
		C-North	11	<5	5,950	<25	9,310	<0.010	0.018	0.147	0.854
Mar-91	McClellan	SB-1	10	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
			20	10	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
		SB-2	10	<5	<10	118	n.a.	n.a.	n.a.	n.a.	n.a.
			20	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
		SB-3	10	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
			20	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
		SB-5	10	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
			15	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
			20	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
		SB-8	10	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
			20	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
		SB-9	10	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
			20	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
		SB-10	10	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
			20	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
		SB-11	10	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
			20	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
		SB-12	6	<5	47	<25	n.a.	n.a.	n.a.	n.a.	n.a.
			10	3,900	611	<50	n.a.	n.a.	n.a.	n.a.	n.a.
		SB-13	2	6,410	3,060	<25	n.a.	n.a.	n.a.	n.a.	n.a.
			8	3,330	405	<25	n.a.	n.a.	n.a.	n.a.	n.a.
		SB-14	5	1,400	91	<25	n.a.	n.a.	n.a.	n.a.	n.a.
			10	2,670	<20	<50	n.a.	n.a.	n.a.	n.a.	n.a.
May-91	McClellan	A 13	13	<5	<10	<25	n.a.	n.a.	n.a.	n.a.	n.a.
		B 13	13	<5	621	<25	n.a.	n.a.	n.a.	n.a.	n.a.
		C 13	13	201	36	27	n.a.	n.a.	n.a.	n.a.	n.a.
		D 13	13	1,850	280	<25	n.a.	n.a.	n.a.	n.a.	n.a.

<12 : Below given reporting limit

n.a. : Not Analyzed

TPH-g : Total Petroleum Hydrocarbons as gasoline

TPH-d : Total Petroleum Hydrocarbons as diesel

TPH-mo : Total Petroleum Hydrocarbons as motor oil

TRPH : Total Recoverable Petroleum Hydrocarbons

Table 2.2
Soil Analytical Results for Petroleum Hydrocarbons
Deep Soil Borings, Site ST200
McClellan AFB, California

Sample Date	Contractor	Boring No.	Depth (bgs)	Total Petroleum Hydrocarbons ¹		Purgeable Aromatics ¹			
				Method: 8015 (Mod.)		8020			
				Analyte:	TPH-g	TPH-d	Benzene	Toluene	Ethyl-benzene
May-93	Jacobs Engineering Group	SA38SB01	15	5,900	330	ND	4.8	28	170
			20	1,200	320	ND	ND	13	69
			30	440	260	ND	0.83	5.1	27
			40	0.43	ND	ND	ND	ND	0.026
			60	ND	ND	ND	ND	ND	ND
			80	ND	ND	ND	ND	ND	ND
			95	ND	ND	ND	ND	ND	ND
		SA38SB02	15	0.26	ND	ND	ND	ND	ND
			20	0.25	ND	ND	ND	ND	ND
			30	4,400	ND	0.011	ND	44	ND
			40	0.93	ND	ND	ND	0.043	0.16
			60	ND	ND	ND	ND	ND	ND
			80	ND	ND	ND	ND	ND	ND
			95	ND	ND	ND	ND	ND	ND
		SA38SB03	15	2,900	780	ND	ND	9.9	21
			20	4.2	ND	ND	ND	ND	ND
			30	ND	420	ND	ND	ND	ND
			40	0.38	ND	ND	ND	ND	0.021
			60	ND	ND	ND	ND	ND	ND
			80	ND	ND	ND	ND	ND	ND
			95	ND	ND	ND	ND	ND	ND
		SA38SB04	15	n.a.	ND	ND	ND	ND	ND
			20	n.a.	140	ND	ND	ND	ND
			30	n.a.	290	ND	ND	ND	ND
			40	ND	ND	ND	ND	ND	ND
			60	ND	ND	ND	ND	ND	ND
			80	ND	ND	ND	ND	ND	ND
			95	ND	ND	ND	ND	ND	ND
Oct-96	Jacobs Engineering Group	SA38SB06	10	ND	n.a.	n.a.	n.a.	n.a.	n.a.
			20	ND	n.a.	n.a.	n.a.	n.a.	n.a.
			40	0.33	n.a.	n.a.	n.a.	n.a.	n.a.
			70	0.17	170	ND	ND	ND	ND
			90	ND	9	ND	ND	ND	ND
		SA38HP001	10	ND	n.a.	n.a.	n.a.	n.a.	n.a.
			20	ND	n.a.	n.a.	n.a.	n.a.	n.a.
			40	ND	n.a.	n.a.	n.a.	n.a.	n.a.
			60	ND	n.a.	n.a.	n.a.	n.a.	n.a.
			80	ND	n.a.	n.a.	n.a.	n.a.	n.a.
			100	ND	n.a.	n.a.	n.a.	n.a.	n.a.

n.a. : Not Analyzed

ND : Not detected at or above the reporting limit

TPH-g : Total Petroleum Hydrocarbons as gasoline

TPH-d : Total Petroleum Hydrocarbons as diesel

¹ The results from SA38SB06 and SA38HP001 are preliminary.

Table 2.3
Soil Vapor Analytical Results for BTEX
Downhole Samples, Site ST200
McClellan AFB, California

Sample Date	Contractor	Boring No.	Depth ³ (bgs)	Aromatic Hydrocarbons ¹				
				Method:	E18/TO-14 ²			
					Benzene	Ethyl-benzene	Total Xylenes	
					Concentrations in ppmv			
May-93	Jacobs Engineering Group	SA38SB01	12	ND	ND	ND	8.5	
			22	ND	ND	ND	160	
			42	ND	ND	ND	55	
			62	ND	4.0	ND	26	
			82	ND	2.7	ND	44	
			97	ND	ND	ND	9.7	
		SA38SB02	12	ND	ND	ND	0.078	
			22	ND	ND	ND	2.5	
			42	ND	ND	ND	106	
			62	ND	20	ND	12	
			82	ND	4.5	ND	17	
			97	ND	ND	ND	39	
		SA38SB03	12	ND	ND	ND	0.19	
			22	44	12	ND	130	
			42	33	28	ND	130	
			62	ND	ND	ND	27	
			82	2.9	4.2	ND	39	
			97	ND	ND	ND	8.2	
		SA38SB04	12	ND	ND	ND	0.073	
			22	ND	8.7	ND	28	
			42	4.2	4.6	ND	70	
			62	4.4	6.4	ND	4.8	
			82	ND	1.6	ND	3.4	
			97	0.42	0.84	0.98	4.4	
Oct-96	Jacobs Engineering Group	SA38SB06	21	0.0099	0.016	ND	0.49	
			40	34	19	130	420	
			60	0.78	0.74	12	50	
			78	0.26	0.54	11	50	
			92	0.14	0.39	6.5	28	
		SA38HP001	20	0.0069	0.0087	0.0014	0.0050	
			40	0.0062	0.0078	ND	0.0029	
			60	0.0065	0.0088	0.0014	0.0058	
			80	0.0086	0.013	0.0030	0.0070	
			100	0.0055	0.0090	ND	0.0026	

n.a. : Not Analyzed

ND : Not detected at or above the reporting limit

Notes:

¹ Some of the data was qualified. Refer to RI report for data qualifiers (JEG, 1995).

The results from SA38SB06 and SA38HP001 are preliminary.

² The sample taken from SA38SB04 at 97 ft bgs was analyzed by both Methods E18 and TO-14; the maximum concentrations are reported.

³ Boring SA38SB06 was installed 18 degrees from vertical. The corrected depths are shown.

Table 2.4
Soil Vapor Analytical Results for Other Petroleum Hydrocarbons
Downhole Samples, Site ST200
McClellan AFB, California

Method:	Analyte:	Volatile Organic Compounds ¹								Propene
		1,2,4-trimethylbenzene	1,3,5-trimethylbenzene	1,3-butadiene	cyclohexane	hexane	MTBE	n-octane	2,2,4-dimethylpentane	
Sample Date		Concentrations in ppmv								
May-93	SA38SB04	97	5.6	2.3	0.063	ND	n.a.	ND	5.1	ND
	SA38SB06	21	0.25	0.53	n.a.	0.21	0.073	ND	n.a.	ND
		40	58	29	n.a.	370	41	51	ND	ND
		60	14	6	n.a.	16	1.1	1.0	ND	ND
			78	22	8.4	n.a.	110	0.4	0.3	ND
			92	11	4.3	n.a.	5.3	0.3	0.1	n.a.
			Oct-96	20	0.0014	0.0015	n.a.	0.0060	0.0025	0.0066
	SA38HP001			40	ND	n.a.	0.0052	ND	0.0033	n.a.
				60	0.0012	ND	0.0074	ND	0.010	0.0013
				80	0.0016	ND	0.0080	0.0014	n.a.	0.0084
				100	ND	n.a.	0.017	0.0026	ND	0.0076
						n.a.	0.010	0.0079	0.017	ND

n.a. : Not Analyzed

ND : Not detected at or above the reporting limit

MTBE : Methyl Tertiary Butyl Ether

Notes:

¹ Some of the data was qualified. Refer to RI report for data qualifiers (JEG, 1995). BTEX results shown in Table 2.3.

The results from SA38SB06 and SA38HP001 are preliminary.

² The sample taken from SA38SB04 at 97 ft bgs was analyzed by both Methods E18 and TO-14; the maximum concentrations are reported.

³ Boring SA38SB06 was installed 18 degrees from vertical. The corrected depths are shown.

Table 2.5
Soil Vapor Analytical Results for HVOCs and Other VOCs
Downhole Samples, Site ST200
McClellan AFB, California

Method:	Sample Date	Boring No.	Depth ³ (bgs)	Halogenated Volatile Organic Compounds ¹												Other VOCs ¹			
				CCl ₄	Chloro-methane	Chloro-form	1,2-DCA	1,1-DCE	cis-1,2-DCE	trans-1,2-DCE	DCE	Freon-11	Freon-12	Freon-113	MeCl	PCE	TCE	VC	Acetone
Concentrations in ppmV																			
May-93	SA38SB01	12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		62	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		82	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		97	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	SA38SB02	12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		62	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		82	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		97	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	SA38SB03	12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		62	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		82	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		97	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	SA38SB04	12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		62	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		82	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		97	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	SA38SB05	21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		40	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		60	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		78	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		92	0.18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		20	0.0065	ND	0.0014	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		40	0.061	ND	0.0075	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		60	0.073	0.0080	0.0072	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		80	0.28	0.026	0.025	0.038	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		100	0.45	0.013	0.066	0.060	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

n.a. : Not Analyzed
ND : Not detected at or above the reporting limit

Notes:
¹ Some of the data was qualified. Refer to RI report for data qualifiers (JEG, 1995).
The results from SA38SB06 and SA38HP001 are preliminary.
² The sample taken from SA38SB04 at 97 ft bgs was analyzed by both Methods E18 and TO-14; the maximum concentrations are reported.
³ Boring SA38SB06 was installed 18 degrees from vertical. The corrected depths are shown.

DCE : dichloroethene
DCA : dichloroethane

VC : vinyl chloride
PCE : tetrachloroethene

CCl₄ : carbon tetrachloride
MeCl : methylene chloride

The downhole soil vapor analytical results for BTEX compounds and other petroleum hydrocarbon related compounds are shown in Tables 2.3 and 2.4. Although at least one of the BTEX or petroleum hydrocarbon related compounds were detected in all samples, concentrations were generally highest in the samples collected from 22 and 42 feet bgs, consistent with the analytical results for soil samples. The maximum detected BTEX concentrations during the Phase I RI sampling were: 44 part per million by volume (ppmv) benzene, 28 ppmv toluene, 0.98 ppmv ethylbenzene, and 130 ppmv total xylenes. Concentrations generally showed a decreasing trend with depth.

Halogenated VOCs and non-petroleum hydrocarbon VOCs were also detected in downhole soil vapor samples (Table 2.5). The maximum concentrations of halogenated VOCs measured at concentrations greater than 1.0 ppmv were: 3.8 ppmv PCE, 1.2 ppmv TCE, 20 ppmv 1,1-DCE, 34 ppmv cis-1,2-DCE, 16 ppmv trans-1,2-DCE, and 9.1 ppmv vinyl chloride. Concentrations were generally highest in the samples collected from 22 and 42 feet bgs, where the highest concentrations of petroleum hydrocarbons were measured in soil and soil vapor samples. However, no sources of halogenated VOCs have been attributed to Site ST200. The compounds with the highest concentrations (1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride) are potential anaerobic biodegradation daughter products of TCE, PCE, and carbon tetrachloride and the vadose zone soils near the petroleum hydrocarbon contamination are probably anoxic. Therefore, the detection of these compounds at the shallower depths is likely a result of the dehalorespiration of low concentration soil residuals or migrating soil vapor, rather than an indication of a significant vadose zone source of halogenated VOCs.

Of the detected halogenated VOCs, PCE, 1,1-DCE, and cis-1,2-DCE were identified in the RI as chemicals of potential concern (COPC) due to migration of soil gas contaminants to groundwater (JEG, 1995).

2.3.3 Additional Site Characterization Activities

In late 1996, additional site characterization activities were conducted based on the Phase I RI report recommendations for ST200 (JEG, 1996). Two borings, SA38SB06 and SA38HP001, were advanced at the site. SA38SB06 was a slant boring advanced beneath the west side of Building 26 and SA38HP001 was a vertical boring advanced southwest of the former UST excavation (Figure 2.3). Soil and soil vapor samples were collected at approximately 20-foot intervals to a depth of 100 feet bgs. Soil samples were analyzed for TPH-g, TPH-d, BTEX, metals, and organic lead. Soil vapor samples were analyzed for VOCs. Boring SA38HP001 was advanced to groundwater and a Hydropunch® groundwater sample was collected for laboratory analysis. Analytical results from the additional sampling activities are included in Tables 2.2 through 2.5; however, all results from SA38SB06 and SA38HP001 are preliminary (JEG, 1996).

Residual soil contamination was detected at greater depths than during earlier subsurface investigations. TPH-g was detected at concentrations of 0.33 mg/kg at 40 feet bgs and 0.17 mg/kg at 70 feet bgs in SA38SB06. TPH-d was detected at concentrations of 170 mg/kg at a depth of 70 feet bgs and 9 mg/kg at a depth 90 feet bgs in SA38SB06. The magnitude of

the maximum concentration for TPH-g was significantly lower in SA38SB06 than in previous soil borings. However, the slant boring was drilled through relatively uncontaminated soil outside the former excavation in the upper depths (less than 60 feet bgs) and only reached impacted soil underneath Building 26 at depths greater than approximately 60 feet bgs.

In soil vapor, the maximum concentration of BTEX compounds measured during the additional sampling activities were: 34 ppmv benzene, 19 ppmv toluene, 130 ppmv ethylbenzene, and 422 ppmv total xylenes (all detected in the sample collected from SA38SB06 at a depth of 42 bgs). Ethylbenzene was detected at significantly higher concentrations during the additional sampling activities than during Phase I RI activities. BTEX concentrations were well below 1.0 ppmv at SA38HP001, which was installed farthest from the source area and primarily located to evaluate downgradient groundwater impacts. The soil vapor results are consistent with the previous soil vapor results during the Phase I RI.

Tables 2.4 and 2.5 present the soil vapor analytical results for other petroleum hydrocarbons and halogenated VOCs for the additional sampling activities. The soil vapor concentrations for the anaerobic biodegradation breakdown products (i.e., TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride) were significantly less than those measured during the Phase I sampling, probably because the vadose zone soils have a higher oxygen content in locations sampled by the additional activities. In addition, the halogenated VOCs generally show an increasing trend with depth, with the highest concentrations generally measured nearest to groundwater.

Halogenated VOCs were the primary contaminants detected in the Hydropunch® groundwater sample (Table 2.6). However, a concentration of 0.037 mg/L TPH-g was also measured. BTEX was not detected in the groundwater sample.

2.3.4 Summary

The primary contaminants attributable to ST200 are petroleum hydrocarbons. Although halogenated VOCs were also detected in soil vapor, none were detected in soil. These detections are likely related to off-gassing from the regional groundwater plume of halogenated VOCs, from adjacent sites SA37 and SA39, or from residuals within the groundwater smear zone (JEG, 1995). During removal of the USTs, hydrocarbon contamination was observed beneath Building 26 and beneath the excavation pit. Soil and soil vapor sampling at ST200 has confirmed that the area immediately adjacent to and beneath Building 26 contains the highest concentrations of residual fuel contaminants.

Additional sources of residual fuel contamination may include soils underneath the former UST excavation area, the former fuel island east of Building 26, and the north side of Building 26. Based on previous sampling activities, the vertical and horizontal extent of vadose zone contamination appears to be well-defined except for north side of Building 26. Most of the residual soil contamination appears to be limited to depths between 15 and 40 feet bgs. Groundwater beneath the site has been impacted by halogenated VOCs and TPH-g, but the halogenated VOCs are presumed to originate from off-site sources. Although halogenated VOCs were measured in soil vapor, there does not appear to be a significant

Table 2.6
Groundwater Analytical Results for HVOCs and TPH
Site ST200
McClellan AFB, California

Method:	Halogenated Volatile Organic Compounds ¹								Petroleum Hydrocarbons ¹	
	SW8260A								SW8015M	
Analyte:	CCl ₄	Chloro-form	1,2-DCA	Freon-11	Freon-12	MeCl	PCE	TCE	TPH-g	
Sample Date	Location	Concentrations in $\mu\text{g/L}$								Concentration in mg/L
Oct-96	SA38HP001	3.3	4.9	2.5	0.73	0.28	0.21	0.58	1.5	0.037

TPH-g : Total Petroleum Hydrocarbons as gasoline

DCA : dichloroethane

CCl₄ : carbon tetrachloride

MECl : methylene chloride

PCE : tetrachloroethene

TCE : trichloroethene

Notes:

¹ Preliminary results.

source of non-petroleum hydrocarbons at the site. Based on the detection of anaerobic dehalorespiration daughter products in soil vapor, there appears to be some anaerobic biodegradation of halogenated VOCs occurring in the vadose zone.

SECTION 3

SITE-SPECIFIC ACTIVITIES

The purpose of this section is to describe the work that will be performed by Parsons ES. Activities that will be performed include siting and construction of up to 2 vent wells (VWs) and up to 5 vapor monitoring points (VMPs), an initial pilot test (including *in situ* respiration tests and an air permeability test), and installation of a long-term bioventing system. Soil and soil vapor sampling procedures and the blower configuration that will be used to introduce air (oxygen) into contaminated soils are also discussed in this section.

Subsurface soils are expected to be composed of mostly interbedded sands and silts which should be suitable for the bioventing technology. Soil moisture data (Section 2.3.2) indicate that the subsurface soils contain sufficient moisture to sustain some degree of respiration and biodegradation. Based on previous bioventing pilot tests conducted at McClellan AFB, soils are expected to contain sufficient nutrient levels; however, these levels will be measured during initial soil sampling.

No dewatering or groundwater treatment will take place during the pilot testing. Pilot test activities will be confined to remediation of petroleum hydrocarbons in vadose zone soils.

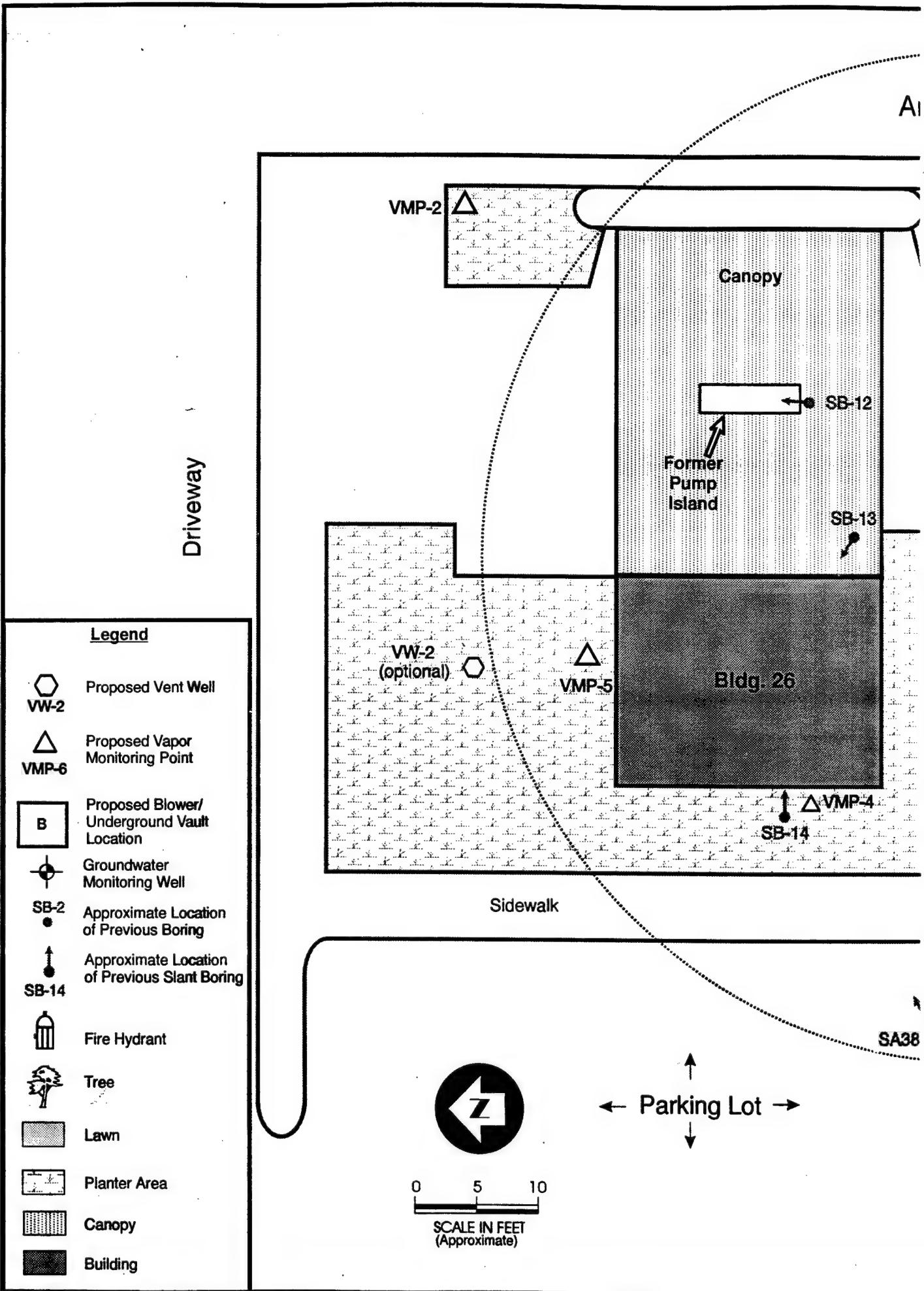
3.1 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

To achieve all quality assurance/quality control (QA/QC) objectives, all site-specific activities will follow the standard operating procedures (SOPs) described in the Basewide RI/FS Quality Assurance Plan (QAP) for McClellan AFB (McClellan AFB, 1994) unless specific exceptions or variations to the SOPs are noted in the following sections. Additional QA/QC objectives specific to bioventing operations are detailed in the Program Quality Assurance Project Plan for AFCEE Bioventing Pilot Tests (ES, 1993).

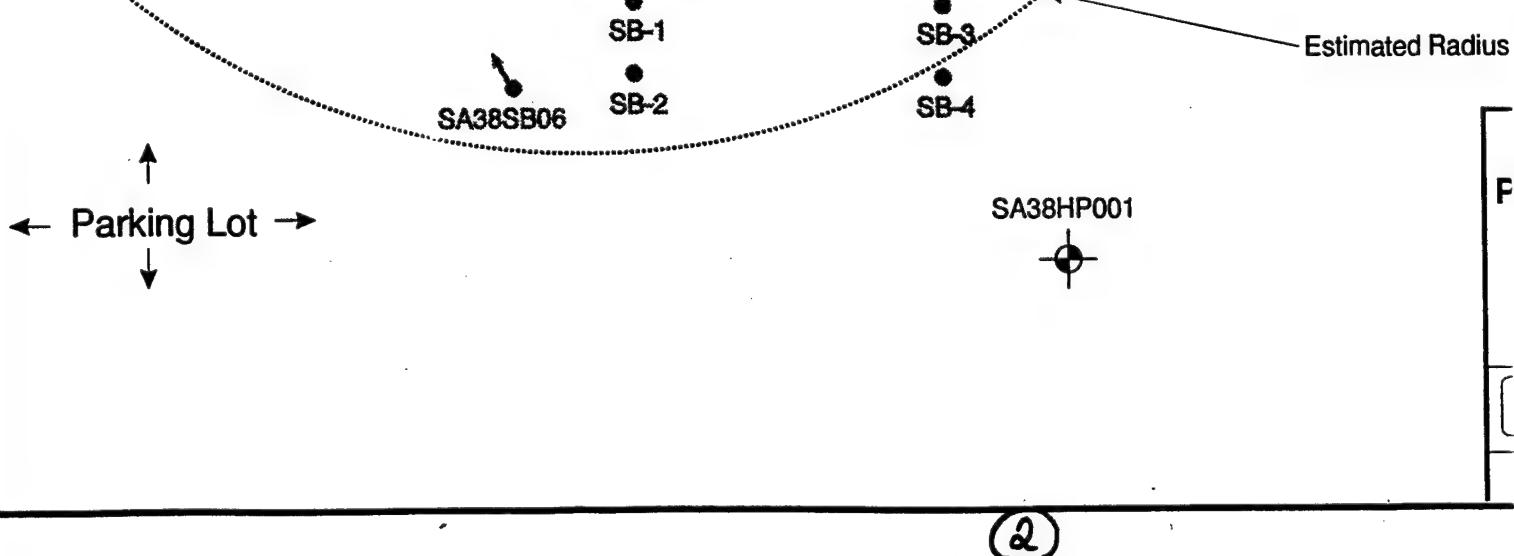
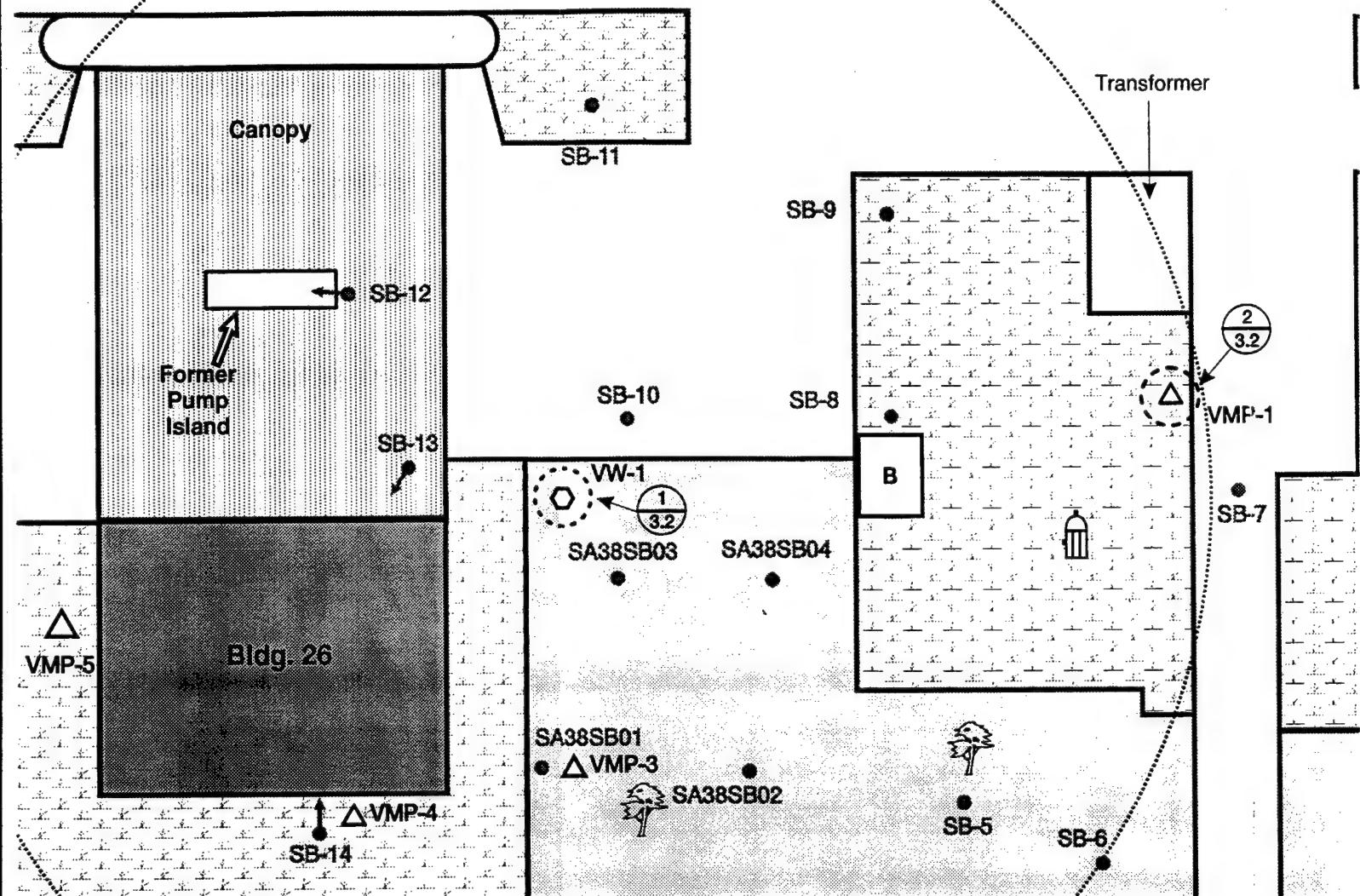
3.2 LOCATIONS OF VENT WELLS (VWS) AND VAPOR MONITORING POINTS (VMPs)

Based on the previous site investigation data (Section 3), the area immediately adjacent to and beneath Building 26 contains the highest concentrations of residual fuel contaminants. Additional sources of residual fuel contamination may include soils underneath the former UST excavation area, the former fuel island east of Building 26, and the north side of Building 26.

General criteria used for siting VWs and VMPs are included in the protocol documents (Hinchee et al., 1992; Leeson and Hinchee, 1995). Figure 3.1 shows the proposed locations



Arnold Avenue



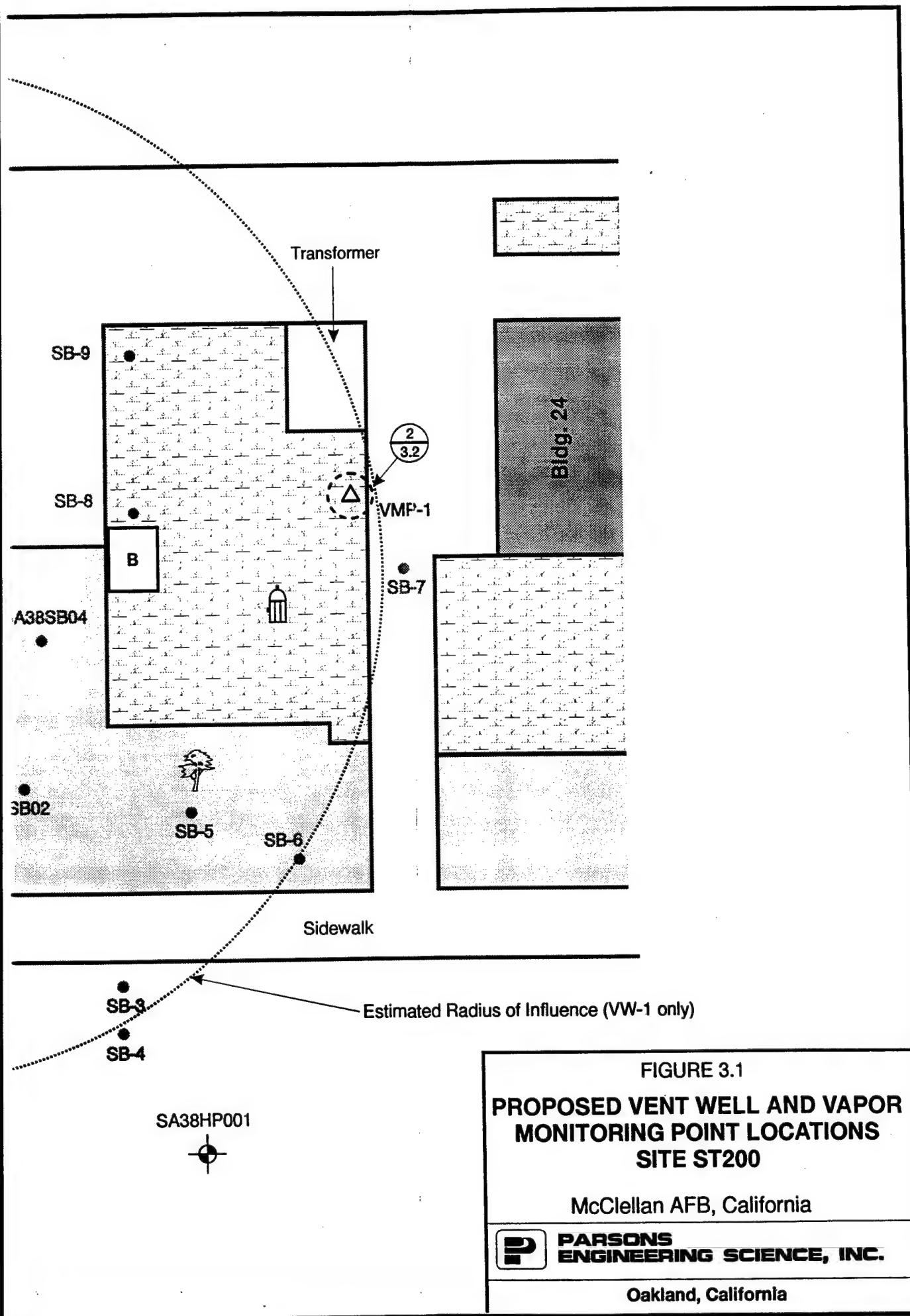


FIGURE 3.1
PROPOSED VENT WELL AND VAPOR
MONITORING POINT LOCATIONS
SITE ST200

McClellan AFB, California



PARSONS
ENGINEERING SCIENCE, INC.

Oakland, California

of the VW(s) and VMPs. The proposed location of VW-1 is on the southeast side of Building 26. This location for VW-1 was chosen so that the treatment radius from VW-1 would encompass all the known areas of soil contamination, but minimize the potential for contaminant vapors to migrate toward Building 24, which is currently occupied.

The proposed location for VW-1 and the expected treatment radius of 40 to 50 feet should be sufficient to remediate all contaminated soil underneath the former UST excavation, Building 26, and the former fuel island. The estimated treatment radius of 40 to 50 feet based on the composition of the soils at ST200 and based on bioventing pilot tests performed at other Base sites. An optional VW, designated VW-2, may be installed if field evidence of contamination is detected on the north side of Building 26 (i.e., during installation of VMP-5) or if the treatment radius measured during the AP test indicates that the treatment radius does not encompass known contaminated soils.

Up to a total of 5 VMPs will be located within the expected radius of influence from VW-1. All VMPs will be used to measure pressure response during bioventing operations and used to estimate the treatment radius from the VW(s). At the request of McClellan AFB, all VW(s) and VMPs were located within planter box or grass areas to preserve the integrity of the site and maintain the historical nature of the Building. Therefore, VMPs were not located beneath the former pump island or underneath the canopy.

The location of VMP-1 was chosen primarily to monitor potential vapor migration toward Building 24. Based on previous sampling results, this location is not expected to be contaminated. The location of VMP-2 was chosen along the air flow pathway from VW-1 toward the former fuel island to verify that the soils beneath the former pump island are within the treatment area. Pressure response and changes in soil vapor concentration in both VMP-2 and other VMPs will be used to infer that soils underneath the former fuel island are within the treatment area.

The locations of VMP-3, VMP-4, and VMP-5 were chosen within or immediately adjacent to areas of known contamination and will be the primary VMPs where soil and soil vapor sampling and *in situ* respiration (ISR) tests will be conducted. The location of VMP-5 was chosen to evaluate the horizontal extent of contamination on the north side of Building 26.

The final locations of the VW(s) and VMPs may vary from the proposed locations if evidence of significant fuel contamination is not observed where expected (i.e., VW-1, VMP-3, and VMP-4) or if significant fuel contamination is observed in unexpected areas (i.e., north of Building 26). The VW(s) will be located so that the treatment radius encompasses areas of fuel contamination which are also expected to be oxygen depleted (less than 5%). Increased biological activity should be stimulated by oxygen-rich soil gas ventilation during both the initial pilot test and long-term air injection operations.

3.3 BOREHOLE ADVANCEMENT AND SAMPLE COLLECTION

Boreholes will be advanced using a hollow stem auger (HSA) drill rig equipped with 8-inch and 10-inch outside-diameter (OD) hollow-stem augers. The 10-inch augers will be used to advance the pilot hole for the VW and the 8-inch augers will be used for VMPs. Soil

samples will be collected every 5 feet for logging purposes and at significant lithologic changes. Soil samples will be collected in a 2-inch inside-diameter (ID) split-barrel sampler. The split-barrel sampler was fitted with three pre-cleaned, 2-inch OD by 6-inch long, thin-walled, stainless steel or brass sleeves.

Due to the extensive downhole soil vapor sampling previously conducted at the site, no downhole soil vapor sampling is proposed during drilling and installation of the VW(s) and VMPs for the bioventing system. However, *in situ* soil vapor samples will be collected from the new VW and VMPs, as described in Section 3.6.

3.4 CONSTRUCTION OF VENT WELL(S) (VWS)

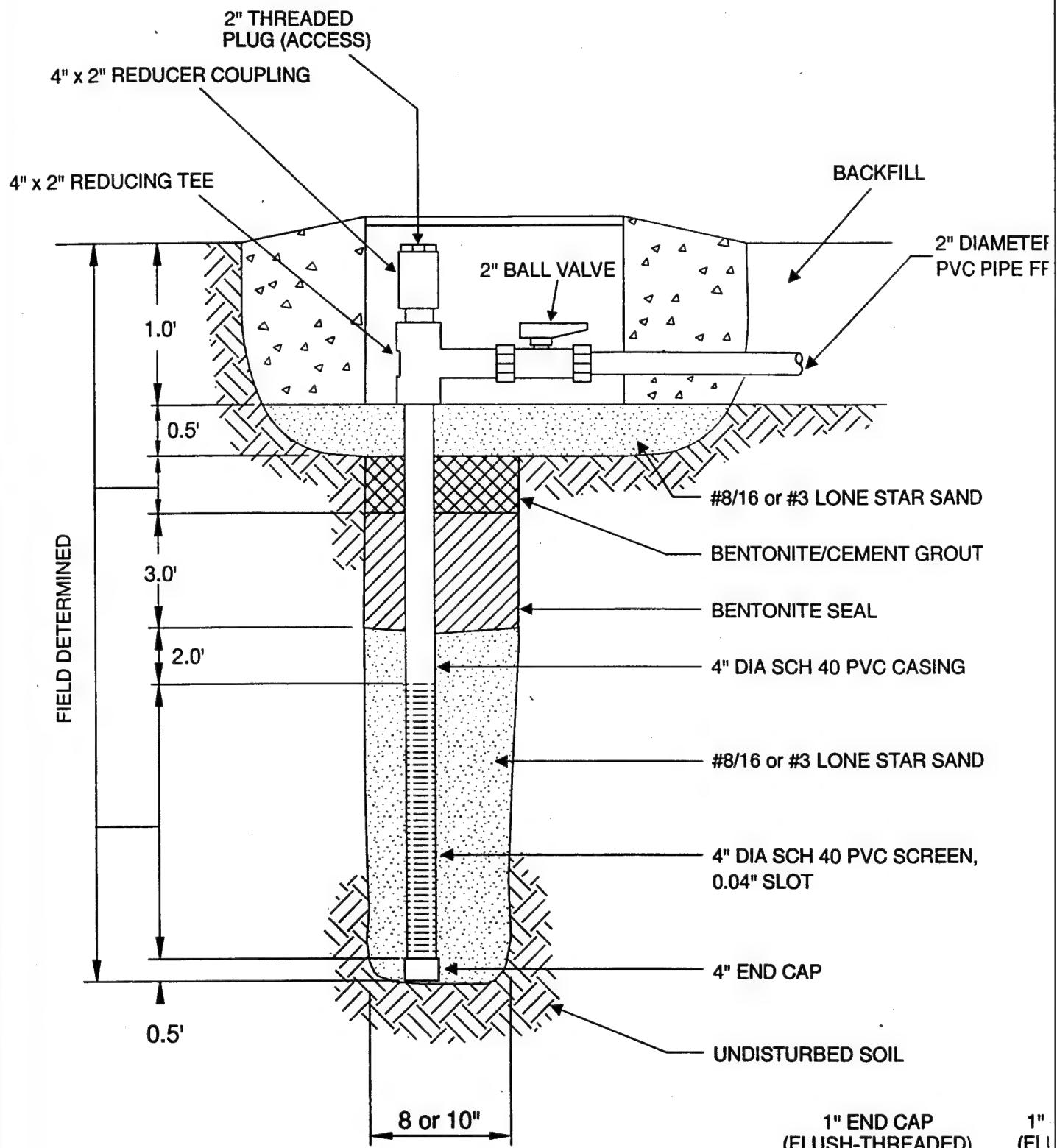
Figure 3.2 shows construction details for the proposed VW(s). The VWs will be constructed of 4-inch inside diameter (ID) Schedule 40 polyvinyl chloride (PVC) casing, with an interval of 0.040-inch slotted screen. The screened interval will be between the initially encountered contamination (but a minimum of 5 feet bgs) down to the base of contamination as determined by field organic vapor analysis (OVA) of soil sample head space. The top of the screen interval may be set lower than the uppermost zone of soil contamination to prevent short-circuiting of injected air within any near-surface zone of high permeability (e.g., the former excavation backfill material).

The depth selected as the base of contamination will be based on an evaluation of physical and visual evidence of contamination (e.g. odors and staining), site lithology, as well as headspace screening using both a total volatile hydrocarbon analyzer (TVHA) and a photoionization detector (PID). The TVHA is a platinum catalyst combustion detector calibrated with hexane, which provides a conservative reading representative of total petroleum hydrocarbon vapors present. Two to three additional headspace readings will be taken at increasing depths beyond the apparent end of contamination to ensure that the vertical extent of contamination has been delineated. Based on previous soil borings and soil vapor monitoring, it is estimated that the maximum depth of the VWs will be between 40 and 60 feet bgs.

Flush-threaded PVC casing and screen will be used with no organic solvents or glues. The filter pack will be a clean Lone Star sand with a #8/16 or #3 grain size and will be placed in the annular space of the screened interval. A 3-foot layer of bentonite will be placed directly over the filter pack. The remainder of the annular space, except for a 2-foot open area directly below the ground surface, will be filled with a bentonite/cement grout. A complete seal is critical to prevent the short-circuiting of air from the surface during air injection. Additional details on VW construction are found in Section 4 (Hinchee et al., 1992) and Volume II, Section 2.5 (Leeson and Hinchee, 1995) of the protocol documents.

3.5 CONSTRUCTION OF VAPOR MONITORING POINTS (VMPs)

Figure 3.2 shows the construction detail for the proposed VMPs. The VMPs will be constructed of 0.50-inch ID, Schedule 80 PVC casing and 1-inch ID slotted screen intervals (0.020-inch slot size). Flush threaded PVC casing and screen will be used with no organic

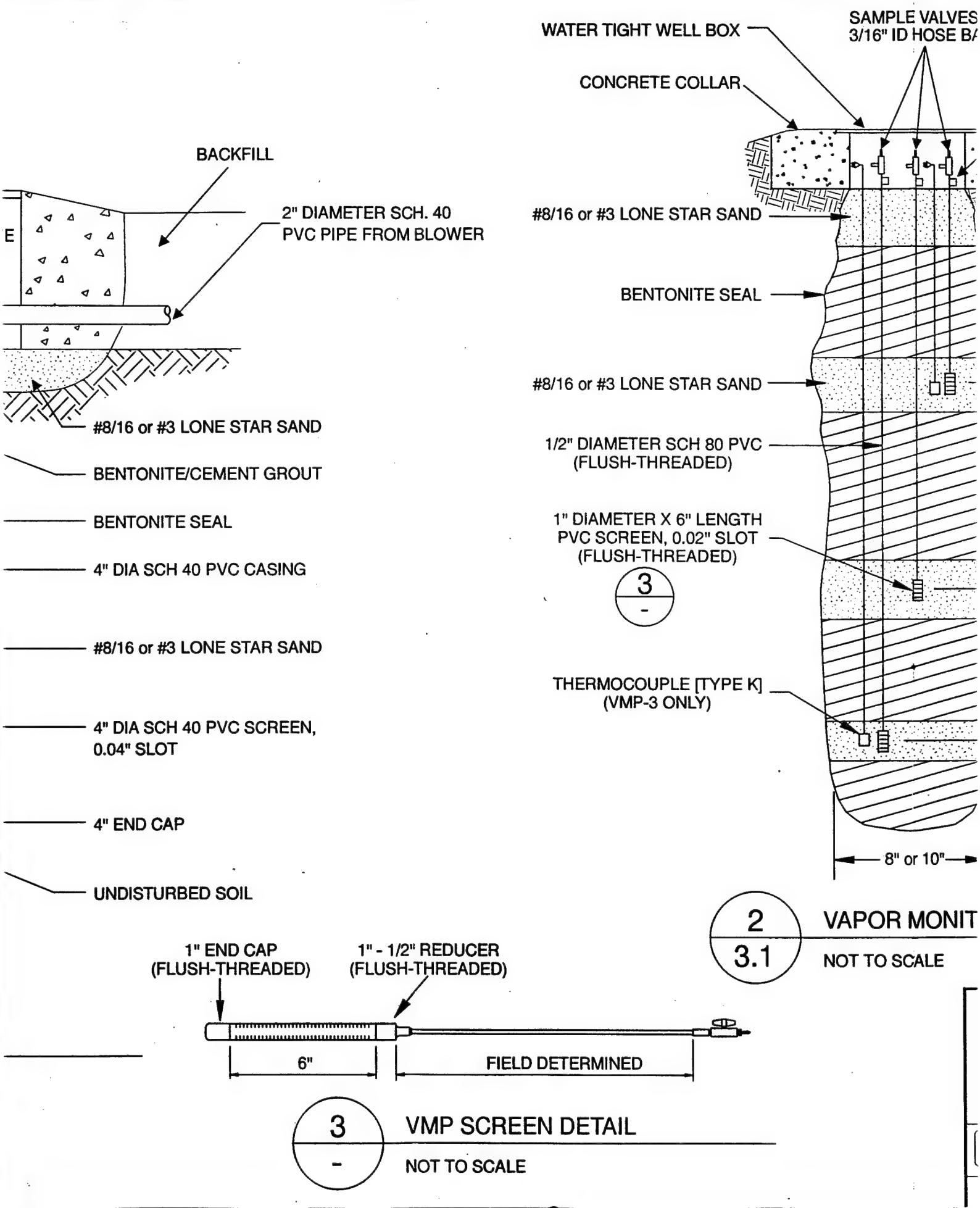


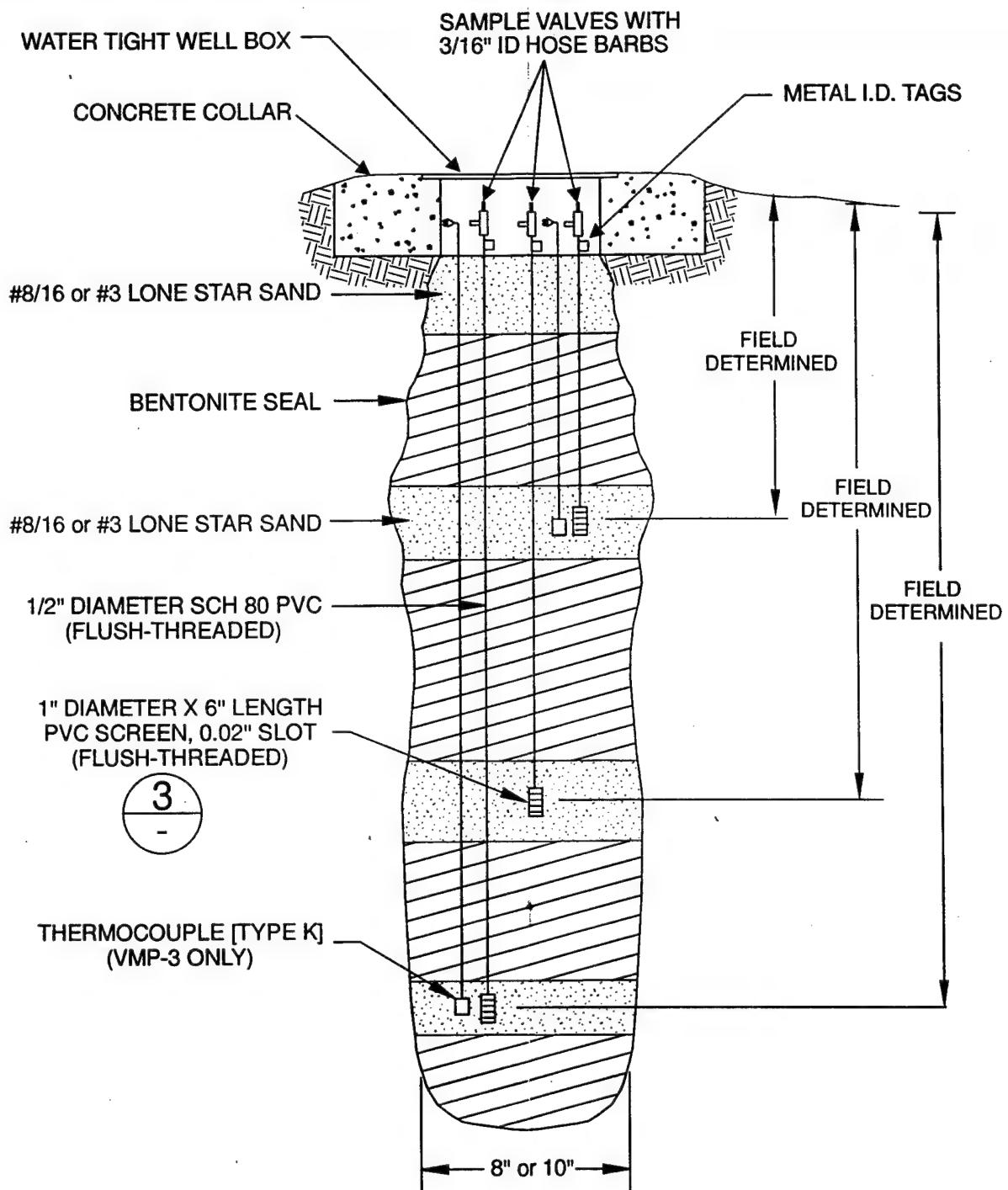
1
3.1

VENT WELL DETAIL

NOT TO SCALE

3
-





VAPOR MONITORING POINT DETAIL

NOT TO SCALE

FIGURE 3.2

CONSTRUCTION DETAILS FOR PROPOSED VWs AND VMPs

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solvents or glues. The annular space between the vapor monitoring screen filter packs will be sealed with a bentonite seal to isolate the monitoring intervals.

The VMPs will be screened to a maximum of three depths. Depths will be selected which provide good vertical coverage between the ground surface and the base of contamination and through different soil types. Multi-depth monitoring will determine the concentration of oxygen across the entire soil profile and will be used to calculate oxygen-utilization rates and fuel biodegradation rates at all monitored depths. The deepest screen will be placed at or near the bottom of contamination as determined by field instrumentation. Oxygen and carbon dioxide concentrations in soil vapor will be monitored using these vapor monitoring screens. Additional details on VMP construction are found in Section 4 (Hinchee et al., 1992) and Volume II, Section 2.6 (Leeson and Hinchee, 1995) of the protocol documents. The VMP construction in the protocol documents varies slightly from SOP McAFB-006 on construction of vapor piezometer nests; however, the VMPs are designed for low-pressure bioventing operations rather than high-vacuum soil vapor extraction (SVE) operations and the differences are not expected to be significant.

3.6 SOIL AND SOIL VAPOR SAMPLING

3.6.1 Soil Sampling

At least one soil sample for laboratory analysis will be collected from the borings advanced prior to installation of VW-1, VMP-3, VMP-4, and VMP-5. During prior investigations, contaminated soils were identified in these locations and the vertical extent of contamination was previously delineated. Therefore, the primary purpose of soil sample collection from these borings will be to establish baseline conditions prior to bioventing and to supplement previous analytical sampling with additional information on nutrient conditions (e.g., phosphorus, nitrogen, and iron).

No soil sampling for laboratory analysis is planned for VMP-1 or VMP-2 since these locations are expected to be in uncontaminated areas and are located primarily to evaluate vapor migration and the treatment radius. At the discretion of the field team leader, soil samples for laboratory analysis may be collected from VMP-1 and/or VMP-2 or additional samples may be collected from the other borings to characterize the depth and extent of contamination, especially if contamination appears to be more extensive than encountered during previous investigations.

Soil samples will be collected using a split-spoon sampler containing brass tube liners. Soil samples collected in the brass tubes will be immediately trimmed and the ends sealed with Teflon® fabric held in place by plastic caps. Soil samples collected for inorganic and physical parameters analysis will be collected in brass tubes or placed in other appropriate sample containers. Soil samples will be labeled, wrapped in plastic, and placed in an ice chest for shipment. A completed chain-of-custody record form will accompany the ice chest, which will be shipped for analysis to Inchcape Testing Services Inc., San Jose, California, which has been audited by the U.S. Air Force and which meets all QA/QC and certification requirements for the State of California.

All soil samples will be analyzed for total TPH as gasoline and diesel (SW8015 Modified); BTEX (SW8020); and moisture content (ASTM D2216). At the request of local regulatory agencies, all samples with detectable concentrations of total TPH will also be analyzed for soluble TPH using deionized water extraction (California Title 22, DI-WET Method). Up to 4 soil samples from both contaminated and uncontaminated locations will be analyzed for pH (SW9045), total alkalinity (Standard Method 403); total iron (SW7380), total Kjeldahl nitrogen (USEPA 351.2), and total phosphorus (USEPA 365.3) to establish baseline and background geochemical and nutrient conditions. Up to two soil samples from uncontaminated soils will be analyzed for total organic carbon (TOC) (SW9060) to support any future vadose zone modeling activities necessary to achieve No Further Investigation (NFI) status.

3.6.2 Soil Vapor Sampling

A maximum of six soil vapor samples for laboratory analysis will be collected in SummaTM canisters from the VW(s) and the VMPs which will be installed in contaminated soils (i.e., VMP-3, VMP-4, and VMP-5). Soil vapor samples for laboratory analysis will not be collected from the VMPs installed in uncontaminated soils (i.e., VMP-1 and VMP-2); these VMPs will be used primarily to monitor pressure response, oxygen influence, and potential vapor migration using field instruments. However, at the discretion of the field team leader, additional samples may be collected from locations which are significantly contaminated and/or oxygen-deficient based on field readings. All soil vapor samples collected for laboratory analysis will be analyzed for BTEX and TVH using EPA Method TO-3. Soil vapor samples will be used to establish baseline conditions and used in the future to determine the reduction in contaminant concentrations over time. Soil vapor samples from all VWs and VMPs will be collected for field analysis of oxygen, carbon dioxide, TVH (using the TVHA), and ionizable compounds (using a PID).

Soil vapor samples will be packed to prevent excessive movement during shipment. They will be sent at ambient temperature to prevent condensation of hydrocarbons. A completed chain-of-custody record will accompany the samples, which will be shipped to Air Toxics Ltd. in Folsom, California, which meets all required U.S. Air Force and State of California certification requirements.

3.7 HANDLING OF INVESTIGATION DERIVED WASTES AND EQUIPMENT DECONTAMINATION

Drill cuttings and decontamination fluids will be containerized on site in labeled U.S. DOT-approved 55-gallon drums. Transportation, characterization, and disposal of IDW will be performed by Base personnel. Equipment decontamination procedures will follow the QAP SOPs, with the exception that isopropanol may be substituted for methanol during decontamination of downhole equipment.

3.8 IN SITU RESPIRATION TESTS

In situ respiration (ISR) tests will be performed after collection of baseline soil vapor samples and prior to any air permeability testing or blower operations. The objective of the ISR tests

is to determine the rate at which native soil microorganisms will biodegrade contamination in site soils.

ISR tests will be performed at the VMPs where biodegradation is indicated by initially low oxygen levels and elevated carbon dioxide levels in the soil gas. A mixture of air (20.8 percent oxygen) and 2 to 4 percent helium will be injected into these VMPs for approximately 20 hours to oxygenate local contaminated soils. At the end of the 20-hour period, the air/helium supply will be cut off and oxygen, carbon dioxide, total volatile hydrocarbons (TVH), and helium levels will be monitored for the following 48 to 72 hours. The decline in oxygen levels over time will be used to estimate rates of bacterial degradation of fuel residuals. Helium, an inert gas, will be used as a tracer gas and monitored to identify possible system leaks or short circuits to the surface. Additional details on ISR testing are found in Section 5.7 (Hinchee et al., 1992) and Volume II, Section 1.4 (Leeson and Hinchee, 1995) of the protocol documents.

3.9 AIR PERMEABILITY TESTS

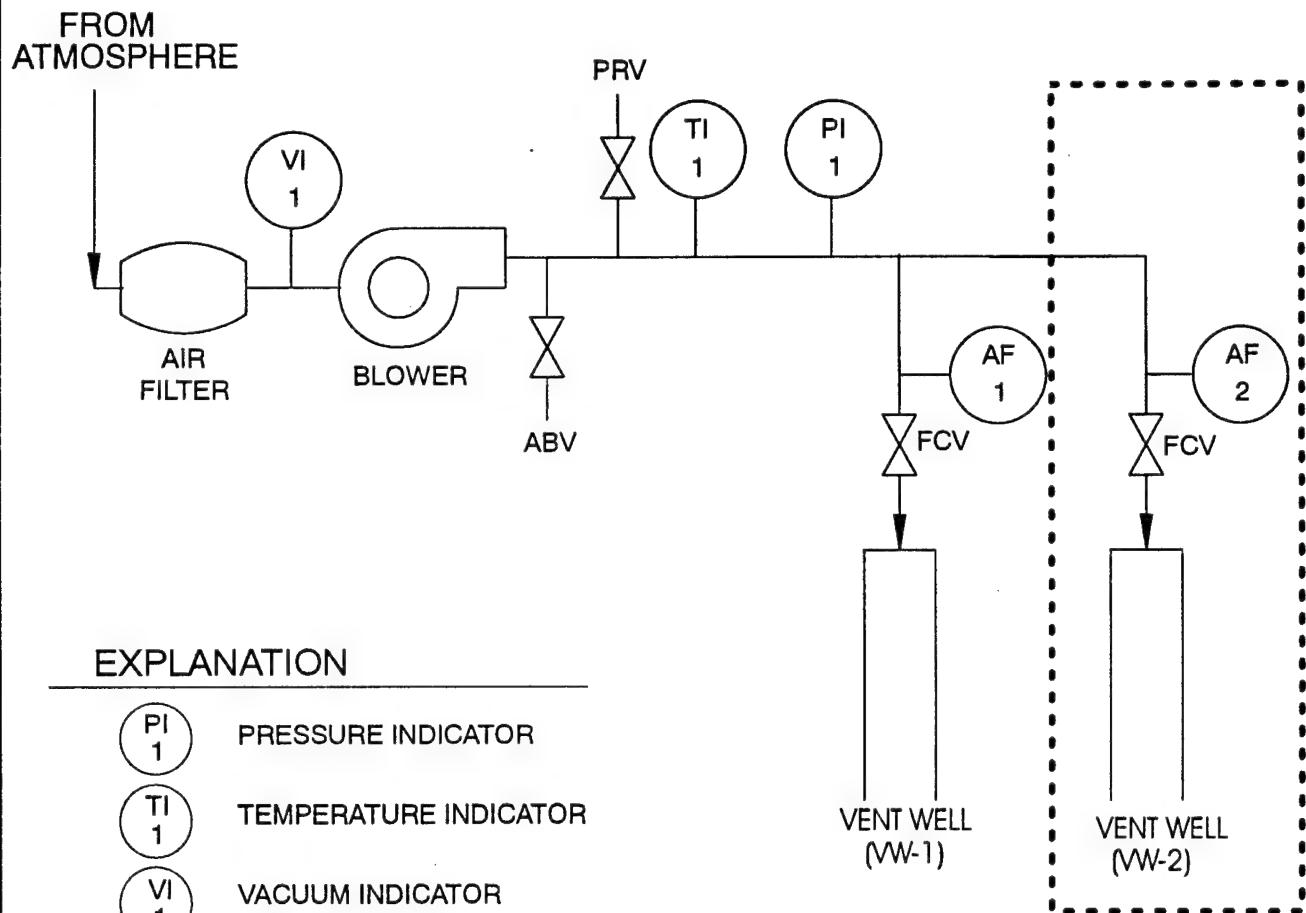
The objective of the air permeability (AP) test is to determine the extent of the subsurface which can be oxygenated from one vent well. Air will be injected into VW-1 using either a portable blower unit or the blower to be used for long-term air injection operations. Pressure response will be measured at each VMP with differential pressure gauges to determine the region influenced by the blower. Oxygen will also be monitored in the VMPs to evaluate oxygen response as a result of air injection. One AP test lasting approximately 8 hours will be conducted. Additional details on the AP test are found in Section 5.6 (Hinchee et al., 1992) and Volume II, Section 1.5 (Leeson and Hinchee, 1995) of the protocol documents.

3.10 BLOWER SYSTEM

A 1.0-horsepower, regenerative blower capable of injecting air at up to 50 standard cubic feet per minute (scfm) at 40 inches H₂O pressure will be installed for long-term air injection operations. The GastTM Model R4 blower currently installed at the Tank Farm #4 (PRL T-18) site will be relocated to ST200 for long-term air injection operations. The Tank Farm #4 site has recently been designated for No Further Investigation status from the local regulatory agencies.

At the request of McClellan AFB, to maintain the historic integrity of the site the blower will be installed below ground in a concrete vault. A sump pump with an automatic level control and external shut-off switch will be installed in the vault. The vault, sump pump, and electrical connection to the vault will be installed by Base personnel or their subcontractors. Parsons ES or its electrical subcontractor will perform the final connection between the electrical supply in the vault and the blower. The maximum power requirement anticipated for the blower is 208-volt, single-phase, 30-amp service. Additional details on power supply requirements are described in Section 5.0, Base Support Requirements. Figure 3.3 is a schematic of a typical air injection system.

After blower installation, continuous air injection at low flow rates (equal to or less than one pore volume exchange per day) will commence. The flow rate will be monitored closely and



EXPLANATION

	PRESSURE INDICATOR
	TEMPERATURE INDICATOR
	VACUUM INDICATOR
ABV	AIR BLEED VALVE
PRV	PRESSURE RELIEF VALVE
FCV	FLOW CONTROL VALVE
	AIR FLOW INDICATOR PORT
	OPTIONAL

FIGURE 3.3
BLOWER PROCESS FLOW
AND INSTRUMENTATION DIAGRAM
FOR AIR INJECTION

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adjusted so that only enough oxygen will be supplied to meet the demand of the indigenous microorganisms. This operating flow rate will be calculated from the oxygen-utilization rate measured during the initial ISR test.

3.11 MONITORING FOR POTENTIAL VAPOR EMISSIONS

Based on prior bioventing experience at McClellan AFB and bioventing studies conducted nationwide, the contaminant concentrations in soil and soil vapor measured at ST200 do not indicate significant potential for vapor migration into Building 24. VW-1 has been sited in a location which will both minimize potential vapor migration and still meet treatment objectives. Based on the previous soil sampling, contaminated soils are not present between the proposed location of VW-1 and Building 24 or east of VW-1 toward the subsurface utilities which run along Arnold Avenue. Although contaminated soils do exist at the former pump island, the radius of influence is not expected to extend to the subsurface utilities from the former pump island and VMP-2 has been located to monitor for such potential vapor migration. Contaminated soils and soil vapor do exist underneath Building 26; however, McClellan AFB staff have agreed to keep Building 26 unoccupied for the duration of bioventing operations or until it can be shown that the bioventing system operation does not present an undue risk to future Building 26 occupants.

Prior to the start of air injection operations, air monitoring using field instruments (PID and TVHA) will be performed within Building 26, Building 24, and along any accessible subsurface utilities to establish baseline conditions. One ambient air sample in both Building 24 and Building 26 will also be collected in a SummaTM canister and submitted for laboratory analysis by EPA Method TO-14 for VOCs. The sampling will occur after normal business hours, as needed, to avoid disruption of any building occupants.

Within 24 hours after long-term air injection operations are initiated, air monitoring using field instruments will be repeated. If field screening levels are above the previously established baseline conditions, an additional SummaTM canister will be collected for laboratory analysis and the blower will be shutdown pending the results of the laboratory analyses. Sampling within a 24-hour period of system startup is considered conservative since the highest potential for vapor migration will occur shortly after system startup when equilibrium concentrations in soil vapor exist and the initial pore volume of soil vapor is being replaced.

3.12 REPORTING

A pilot test results report will be prepared following initial sampling and testing operations. This report will summarize well construction activities, soil and soil vapor sampling results, and ISR and AP test results. Initial estimates of biodegradation rates for fuel-hydrocarbons will also be discussed and recommendations for future testing and monitoring will be made. The report will include an operations and maintenance (O&M) manual for the blower system. The report format will be similar to that used for previous bioventing pilot tests at other McClellan AFB sites (ES, 1994; Parsons ES, 1996a).

SECTION 4

BASE SUPPORT REQUIREMENTS

The following base support is needed prior to the arrival of a driller and the Parsons ES test team:

- Obtain all necessary regulatory concurrence for well installation, sampling, and pilot test activities;
- Obtain any required digging permits and/or permits needed to install vadose zone wells;
- Construct the subsurface concrete vault to hold the blower, provide 208-volt, 30-amp service for the blower to the inside of the vault, and install the sump pump and controls;
- Coordinate with Base electrical or obtain any needed permission to allow Parsons ES subcontractors to perform electrical hookup of the blower;
- Provide any paperwork required to obtain gate passes and security badges for approximately three Parsons ES employees and one driller. Vehicle passes will be needed for two trucks and a drill rig. The passes must be valid for the expected duration of drilling operations and the initial pilot tests (about one month); and
- Provide staff support and Building 24 and 26 access for the after-hours soil vapor sampling, if needed (see Section 3.11).

During the extended air injection operations, the following additional base support items are recommended:

- Base personnel should check the blower system once each week to ensure that it is operating, change filters as needed, and to record air injection pressures and temperatures. Parsons ES will provide an O&M manual, data collection sheets, and a brief training session, if needed.
- If the blower stops working, notify: Mr. Michael Phelps or Mr. Marcus Pierce, Parsons ES-Oakland, (510) 891-9085. However, under the current contract scope of work, major maintenance or future monitoring activities are the responsibility of McClellan AFB.

SECTION 5

PROJECT SCHEDULE

The following schedule is based on the timing requirements anticipated for regulatory agency reviews and approvals and assumes that this draft Work Plan will be submitted to the regulatory agencies in its current form.

Event	Date
Draft Pilot Test Work Plan to McClellan AFB and AFCEE	19 March 1997
Draft Pilot Test Work Plan to Regulatory Agencies	28 March 1997
Comments due from McClellan AFB, AFCEE, and Regulatory Agencies	23 May 1997
Final Pilot Test Work Plan to McClellan AFB, AFCEE, and Regulatory Agencies	20 June 1997
Begin VW and VMP Construction	7 July 1997
Begin ISR and AP Tests	21 July 1997
Completion of all field activities	25 July 1997
Pilot Test Results Report to McClellan AFB, AFCEE, and Regulatory Agencies	October 1997

SECTION 6

POINTS OF CONTACT

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Michael Phelps, Site Manager
Marcus Pierce, Site Geologist/Health and Safety Officer
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(510) 891-9085
Fax (510) 835-4355

John Ratz, Project Manager
Parsons Engineering Science, Inc.
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Denver, CO 80290
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Fax (303) 831-8208

SECTION 7

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APPENDIX A
BORING LOGS FROM PREVIOUS
INVESTIGATIONS AT ST200

LOG OF BORING SA38SB01

PROJECT NAME: MCCLELLAN AIR FORCE BASE - OU A								AIR FORCE BASE MCCLELLAN AFB				
PROJECT NUMBER: 21G11500				LOCATION IDENTIFIER: SA38SB01				SHEET: 1 of 4				
thing: 362188.45 Easting: 2175809.20								Elevation and Datum: 80.00 ft above mean sea level (a.s.l.)				
Health and Safety: Level D with Tyvek								Date Started: 05/17/93		Date Finished: 05/17/93		
Drilling Equipment: CME 750								Total Depth (feet): 97.00		Depth to Groundwater (feet): NA		
Drilling Method: Hollow Stem Auger								Borehole Diameter: 8.00 inches				
Sampling Method: 18 inch Split-Spoon Sampler								Monitoring/Vapor Extraction Well As-Built Total Depth (feet): NA In Figure: NA				
Hammer Information: 190 lb with 30 in drop								Logged by: TL		Checked by: KRL KRL		
Depth (feet)	Blow Counts	Percent Recovery	Sample Interval	Sample ID	OM Reading	USCS Code	Graphic Log	Lithologic Description				Remarks
0-68	8 15 17	94 00		MC-A008949	0.00	GP		GRAVEL: Tank backfill, sand/gravel/minor clay constituents.				
5.00					0.00							
5-7 9	88.00			MC-A008958 MC-A008959 MC-A008891	0.00	GP		GRAVEL: Tank backfill, sand/gravel/minor clay constituents.				
10.00					0.00							
12-32 46	88 00			MC-A008959 MC-A008960 MC-A008892	452.00	ML		SILT: 5Y3/2 dk olv gray, silt w/ minor sand and gravel, sl moist, non pl, dense, strg HC odor.				
15.00					0.00							
8-29 46	100 00			MC-C224301	0.00	ML		SILT 10YR6/4 lt yllw brown, dry, dense, FeOx stain, strg HC odor				
20.00					0.00							
12-23 29	100 00				0.00	SP		SAND: 10YR5/3 brown, subrnd sand, coarsening w/ depth from fn to vry crs, mod graded, moist, md dense,				
25.00					0.00							

LOG OF BORING SA38SB01

PROJECT NAME: MCCLELLAN AIR FORCE BASE - OU A								AIR FORCE BASE MCCLELLAN AFB		
PROJECT NUMBER: 21G11500					LOCATION IDENTIFIER: SA38SB01				SHEET: 2 of 4	
Dep't (feet)	Blow Counts	Percent Recovery	Sample Interval	Sample ID	OMR Reading	USCS Code	Graphic Log	Lithologic Description		Remarks
88								strg HC odor.		
30.00	11 32 39	100.00		HC-A008851 HC-A008893	773.00	ML		SILT: 2.5Y5/3 lt olv brown, silt w/ minor sand interbeds, dry, non pl, dense, FeOx stain, strg HC odor.		
35.00	8 15 23	100.00			700.00	ML		SAND: 10YR4/3 dk brown, vry fn to md, mod graded subrnd sand, moist, dense, strg HC odor.		
40.00	8 15 21	100.00		HC-C224203 HC-C224201	193.00	SP		CLAYEY SILT: 2.5Y5/3 lt olv brown, silt w/ opp 25% clay, sl moist, low pl, md dense, minor FeOx stain, HC odor.		
45.00	6 10 15	100.00		HC-C224302	445.00	ML		SAND: 2.5Y5/2 gray brown, vry fn to md, mod graded subrnd sand, moist, md dense, strg HC odor.		
50.00	10 12 14	100.00			49.00	ML		SANDY SILT: 2.5Y5/4 lt olv brown, silt w/ opp 25% vry fn to fn sand, moist, non pl, md dense, sl HC odor.		
55.00	10 10 20	100.00			77.00	SP		SAND 10YR4/4 dk ylw brown, fn to md sand w/ minor oliv gray silt interbeds, dry, md dense, deep FeOx staining, strg HC odor		
					43.00	SP		SAND 10YR5/3 brown, fn to crs subrnd sand, coarsening w/ depth, dry, loose, sl HC odor		

LOG OF BORING SA38SB01

PROJECT NAME: MCCLELLAN AIR FORCE BASE - OU A

AIR FORCE BASE MCCLELLAN AFB

PROJECT NUMBER: 21611500

LOCATION IDENTIFIER: SA38SB01

SHEET: 3 of 4

Dept (Feet)	Blow Counts	Percent Recovery	Sample Interval	Sample ID	OVH Reading	USCS Code	Graphic Log	Lithologic Description	Remarks
55.00									
60.00	13 14 18	100.00		MC-C224206 MC-C224208	28.00	SP		SAND: 10YR3/3 dk brown, fn to md, md graded subrnd sand, dry, md graded, deep FeOx stain (dry and dense silt in shoe).	
65.00	20 50 0	100.00		MC-C224303	25.00	SM			
70.00	16 25 40	100.00			3.00			SILTY SAND: 2.5Y4/2 dk gray brown, vry fn to fn sand w/ opp 25% silt, sl moist, non pl, dense	
75.00	30 50 0	100.00			0.00	ML		SILT: 2.5Y6/3 lt yllw brown, silt w/ thin crs sand interbed at 70.5 Feet, dry, dense, minor FeOx stain.	
80.00	10 14 36	100.00		MC-C224209 MC-C224207	0.00	ML		SANDY SILT: 2.5Y4/3 lt olv brown, silt w/ opp 20% vry fn to fn sand, dry, dense, minor FeOx stain.	
85.00	16 19 25	100.00		MC-C224304	3.00	ML		SILT: 2.5Y5/3 lt olv brown, silt w/ minor fn sand interbeds, dry, non pl, dense, minor FeOx stain	
					66.00			SILT: 2.5Y5/3 lt olv brown, silt w/ ad sand interbed at 84.75 feet, dry, non pl, dense, some FeOx stain	
					0.00	ML			

LOG OF BORING SA38SB01

PROJECT NAME: McCLELLAN AIR FORCE BASE - DU A

AIR FORCE BASE MCCLELLAN AFB

PROJECT NUMBER: 21G11500

LOCATION IDENTIFIER: SA38SB01

SHEET: 4 OF: 4

LOG OF BORING SA38SB02

PROJECT NAME: MCCLELLAN AIR FORCE BASE - OU A							AIR FORCE BASE MCCLELLAN AFB						
PROJECT NUMBER: 21611500			LOCATION IDENTIFIER: SA38SB02					SHEET: 1	of: 4				
Easting: 362176.85					Elevation and Datum: 80.00 Ft above mean sea level		Date Started: 05/20/93						
Health and Safety: Level D with Tyvek					Date Finished: 05/20/93		Total Depth(Feet): 97.00						
Drilling Equipment: CME 750					Depth to Groundwater(Feet): NA		Monitoring/Vapor Extraction Well As-Built						
Drilling Method: Hollow Stem Auger					Borehole Diameter: 8.00 inches		Total Depth (Feet): NA						
Sampling Method: 18 inch Split-Spoon Sampler					Monitoring/Vapor Extraction Well As-Built		In Figure: NA						
Hammer Information: 140 lb with 30 in drop					Logged by: TL		Checked by: KRL KRL						
Depth (feet)	Blow Counts	Percent Recovery	Sample Interval	Sample ID	OVH Reading	USGS Code	Graphic Log	Lithologic Description			Remarks		
0.00													
5.00	12 22 30	100.00			0.00	GP		GRAVEL: sand, clay, gravel to 0.5 inch, tank backfill.					
10.00	9 11 17	100.00			0.00	GP		GRAVEL: sand, clay, gravel to 1.0 inch, tank backfill.					
15.00	22 38 46	100.00		MC-C228701 HC-C228503 HC-C228501	14.00	ML		SILT: 2.5YS/3 lt ol brown, silt w/ app 10% ad sand, si moist, dense, si HC odor.					
20.00	7 33 49	94.00		MC-C228506 MC-C228504	18.00	ML		SILT: 2.5YS/3 lt ol brown, dry, dense, hard, FeOx stains.					
25.00	5 17 23	100.00		MC-C228702	138.00	ML SP		SILT: 2.5YS/3 lt ol brown, dry, non pl, dense, FeOx stain					
								SAND: 2 SY6/3 lt yllw brown, fn to crs ad graded subrnd sand, moist, ad dense, HC odor, blk discoloration, FeOx stain					

LOG OF BORING SA38SB02

PROJECT NAME: MCCLELLAN AIR FORCE BASE - OU A

AIR FORCE BASE MCCLELLAN AFB

PROJECT NUMBER: 21G11500

LOCATION IDENTIFIER: SA38SB02

SHEET: 2 of 4

Sh. Depth (feet)	Blow Counts	Percent Recovery	Sample Interval	Sample ID	OVM Reading	USCS Code	Graphic Log	Lithologic Description	Remarks
28.00									
30.00	11 24 41	100.00		HC-A0088908 HC-A0088907	277.00	ML	SP	SILT: 2.5YS/3 lt olv brown, dry, non pl, dense, strg HC odor	
35.00	15 17 45	100.00			40.00	ML		SAND: 2.5YS/3 lt olv brown, vry fn to fn sand w/ minor clay, moist, dense, cohesive, FeOx stain, strg HC odor.	
40.00	10 12 34	100.00		HC-A0088963 HC-A0088964	50.00	ML	SP	SILT: 2.5YS/4 lt olv brown, silt w/ minor fn sand, sl moist, non pl, ad dense, FeOx stain, sl HC odor.	
45.00	9 17 24	100.00		MC-C228703	270.00	ML		SILT: 5YS/2 olv gray, sl moist, non pl, ad dense, sl FeOx stain, sl HC odor.	
50.00	7 10 19	100.00			41.00	ML	SP	SILT: 2.5YS/4 lt olv brown, sl moist, non pl, ad dense, some FeOx stain and blk root casts, sl HC odor.	
55.00	10 15 23	100.00			3.00	SP		SAND: 2.5YS/4 lt olv brown, vry fn to fn ad graded subrnd sand w/ minor silt, moist, loose, some FeOx stain.	
					38.00	SP		SAND: 10YRS/3 brown, fn to crs ad graded subrnd sand, dry, loose, some FeOx stain and blk discoloration.	

LOG OF BORING SA38SB02

PROJECT NAME: MCCLELLAN AIR FORCE BASE - OU A

AIR FORCE BASE MCCLELLAN AFB

PROJECT NUMBER: 21G11500

LOCATION IDENTIFIER: SA38SB02

SHEET: 3 of 4

Sh. Depth. (feet)	Blow Counts	Percent Recovery	Sample Interval	Sample ID	OVM Reading	USCS Code	Graphic Log	Lithologic Description	Remarks
55.00									
60.00	10 13 25	100.00		MC-A008955 MC-A008956 MC-C228704	0.00	SP ML		SAND: 10YRS/3 brown, fn to crs ad graded subrnd sand, dry, loose, some FeOx and blk discoloration. SILT: 5YS/2 olv gray, dry, non pl, dense, minor FeOx stain and blk root casts.	
65.00	15 25 50	66.00			0.00	ML		SILT: 2.5YS/4 lt olv brown, silt w/ some fn sand interbeds, dry, non pl, dense.	
70.00	18 31 44	100.00			0.00	ML		SILT: 2.5YS/4 lt olv brown, sl moist, non pl, dense, some blk discoloration.	
75.00	22 34 48	78.00			0.00	ML		SILT: 2.5YS/4 lt olv brown, sl moist, non pl, dense.	
80.00	17 24 39	100.00		MC-A008957 MC-A008958 MC-A008956 MC-C228705	0.00	SP ML		SAND: yllw brown, fn ad sorted subrnd sand, sl moist, dense, some FeOx stain. SILT: 7.5YS/4 lt olv brown, dry, dense, some FeOx stain.	
85.00	27 28 42	100.00			0.00	ML		SILT: 10YRS/3 brown, silt w/ app 10% fn sand, dry, non pl, dense, some FeOx stain and blk root casts.	

LOG OF BORING SA38SB02

PROJECT NAME: McCLELLAN AIR FORCE BASE - OU A

AIR FORCE BASE MCCLELLAN AFB

PROJECT NUMBER: 21G11500

LOCATION IDENTIFIER: SA38SB02

SHEET: 4 OF: 9

LOG OF BORING SA38SB03

PROJECT NAME: MCCLELLAN AIR FORCE BASE - OU A								AIR FORCE BASE MCCLELLAN AFB				
PROJECT NUMBER: 21G11500				LOCATION IDENTIFIER: SA38SB03				SHEET: 1 of 4				
Xing: 362186.62 Easting: 2175821.17				Elevation and Datum: 80.00 ft above mean sea level (a.s.l.)								
Health and Safety: Level D with Tyvek				Date Started: 05/18/93				Date Finished: 05/19/93				
Drilling Equipment: CME 750				Total Depth (Feet): 97.00				Depth to Groundwater (Feet): NA				
Drilling Method: Hollow Stem Auger				Borehole Diameter: 8.00 inches								
Sampling Method: 18 inch Split-Spoon Sampler				Monitoring/Vapor Extraction Well As-Built								
				Total Depth (Feet): NA				In Figure: NA				
Hammer Information: 140 lb with 30 in drop				Logged by: TL				Checked by: KRL KRL				
Depth (feet)	Blow Counts	Percent Recovery	Sample Interval	Sample ID	OVM Reading	USCS Code	Graphic Log	Lithologic Description				Remarks
0.00												
5.00	10 12 16	85.00			1.00	GP		GRAVEL: gravel, sand, clay, tank backfill material				
10.00	12 23 20	100.00			1.00	GP		GRAVEL: gravel, sand, clay, tank backfill material				
15.00	15 35 50	100.00		MC-C225905 MC-A008969 MC-A008970 MC-A008971	473.00	ML		SANDY SILT: 2.5Y4/2 dk gray brown, silt w/ opp 25% sand, dry, non pl, dense, strg HC odor.				
20.00	5 15 18	100.00		MC-C225901 MC-A008971 MC-A008972 MC-A008973	288.00	SP		SAND: 2.5Y5/3 lt olv brown, ad to vry crs well sorted subrnd sand, moist, loose, strg HC odor.				
25.00	15 25 34	100.00			542.00	SP		SAND: 2.5Y4/2 gray brown, ad subrnd sand, sl moist, ad dense, strg HC/gasoline odor				

LOG OF BORING SA38SB03

PROJECT NAME: MCCLELLAN AIR FORCE BASE - OU A

AIR FORCE BASE MCCLELLAN AFB

PROJECT NUMBER: 21G11500

LOCATION IDENTIFIER: SA38SB03

SHEET: 2 of 4

SS Depth (feet)	Blow Counts	Percent Recovery	Sample Interval	Sample ID	OVM Reading	USCS Code	Graphic Log	Lithologic Description	Remarks
25.00									
30.00	10 20 35	100.00		HC-A0088973 HC-A0088993	524.00	ML		SILT: 2.5YS/3 lt olv brown, dry, dense, HC odor, some FeOx stain.	
35.00	8 23 35	100.00			507.00	ML		SAND: 10YR4/4 dk yllw brown, fn to md subrnd sand, moist, ad dense.	
40.00	5 19 20	100.00		HC-C225503 HC-C225501 HC-C225902	98.00	ML		SILT: 2.5YS/3 lt olv brown, silt w/ minor fn sand, sl moist, non pl, ad dense, FeOx stain, strg HC odor.	
45.00	23 35 50	100.00			43.00	ML		SANDY SILT: 2.5YS/3 lt olv brown, silt w/ opp 20% fn sand, moist, loose to ad dense, HC odor.	
50.00	9 14 18	100.00			9.00	SP		SILT: 10YR4/6 dk yllw brown, silt w/ minor vry fn sand, dry, non pl, dense, minor FeOx stain.	
55.00	9 12 20	100.00			1.00	ML		SAND: 10YR5/4 yllw brown, vry fn to md and ad graded subrnd sand, moist, loose.	
								SILT: 2.5YS/3 lt olv brown, moist, non pl, loose, minor FeOx stain.	

LOG OF BORING SA38SB03

PROJECT NAME: MCCLELLAN AIR FORCE BASE - OU A

AIR FORCE BASE MCCLELLAN AFB

PROJECT NUMBER: 21G11500

LOCATION IDENTIFIER: SA38SB03

SHEET: 3 of 4

Depth (feet)	Blow Counts	Percent Recovery	Sample Interval	Sample ID	OVM Reading	USCS Code	Graphic Log	Lithologic Description	Remarks
55.00					1.00	SP		SAND: 10YRS/1 yllw brown, vry fn to fn sand, loose, some FeOx stain.	
59.00	19 20 25	100.00		HC-C225506 HC-C225504	20.00	SP		SAND: 10YRS/3 brown, fn to ad subrnd sand w/ tr silt, dry, loose.	
65.00	11 26 50	100.00		HC-C225903	2.00	ML		SILT: 2.5YS/3 lt olv brown, dry, non pl, dense.	
70.00	17 34 50	100.00			0.00	ML		SILT: 2.5YS/3 lt olv brown, silt w/ some minor fn to ad sand interbeds at 69.50 feet, dry, non pl, dense, minor FeOx stain.	
75.00	12 22 29	100.00			0.00	ML		SILT: 2.5Y4/4 olv brown, silt w/ minor ad sand, dry, non pl, dense.	
80.00	6 11 22	100.00		HC-C225709 HC-C225707	5.00	SP		SAND: 2.5YS/2 gry brown, fn subrnd sand, sl moist, loose.	
85.00	15 19 27	100.00		HC-C225904	0.00	SP		SILT: 2.5YS/3 lt olv brown, dry, non pl, dense, some FeOx stain.	
								SAND: 10YRS/3 brown, ad to crs sand, dry, loose, deep FeOx stain, downward fining to fn.	

LOG OF BORING SA38SB03

PROJECT NAME: MCCLELLAN AIR FORCE BASE - OU A

AIR FORCE BASE MCCLELLAN AFB

PROJECT NUMBER: 21G11500

LOCATION IDENTIFIER: SA38SB03

SHEET: 4 OF: 4

LOG OF BORING SA38SB04

PROJECT NAME: MCCLELLAN AIR FORCE BASE - DU A

AIR FORCE BASE MCCLELLAN AFB

PROJECT NUMBER: 21G11500

LOCATION IDENTIFIER: SA38SB04

SHEET: 1 of 4

Xthing: 362174.19 Easting: 2175820.64

Elevation and Datum: 80.00 Ft above mean sea level (approx.)

Health and Safety: Level 0 with Tyvek

Date Started: 05/21/93

Date Finished: 05/21/93

Drilling Equipment: CME 750

Total Depth(Feet): 97.00

Depth to Groundwater(Feet): NA

Drilling Method: Hollow Stem Auger

Borehole Diameter: 8.00 inches

Sampling Method: 18 inch Split-Spoon Sampler

Monitoring/Vapor Extraction Well As-Built
Total Depth (Feet): NA
In Figure: NA

Hammer Information: 140 lb with 30 in drop

Logged by: TL

Checked by: KRL KRL

Depth (feet)	Blow Counts	Percent Recovery	Sample Interval	Sample ID	OVM Reading	USCS Code	Graphic Log	Lithologic Description	Remarks
0.00									
5.00	9 16 23	83.00			0.00	GP		GRAVEL: Pea gravel (to 1 inch) w/ sand and clay, tank backfill material.	
10.00	15 22 21	66.00			0.00	GP		GRAVEL: Pea gravel (to 1 inch) w/ sand and clay, tank backfill material.	
15.00	10 32 48	100.00		HC-C230501 HC-A008975 HC-A008976 HC-A008900	0.00	ML		SANDY SILT: 2.5Y4/2 dk gray brown, silt w/ opp 25% fn sand, sl moist, dense, strg HC odor.	
20.00	7 18 40	100.00		HC-A008977 HC-A008978 HC-A008901	0.00	ML		SILT: 2.5Y5/3 lt olv brown, dry, non pl, dense, FeOx stain, strg HC odor	
25.00	17 21 20	100.00		MC-C230502	0.00	SP		SAND: 2.5Y5/4 lt olv brown, vry fn to fn ad graded subrnd sand, moist, ad dense, strg HC odor.	

LOG OF BORING SA38SB04

PROJECT NAME: MCCLELLAN AIR FORCE BASE - D1 A

AIR FORCE BASE MCCLELLAN AFB

PROJECT NUMBER: 21G11500

LOCATION IDENTIFIER: SA38SB04

SHEET: 2 of 4

Dep. (feet)	Blow Counts	Percent Recovery	Sample Interval	Sample ID	OVM Reading	USCS Code	Graphic Log	Lithologic Description	Remarks
0.00									
10.23 45	100.00			MC-A008979 MC-A008980	0.00	ML		SANDY SILT: 10YR4/3 dk brown w/ some 5Y5/1 gray interbeds, silt w/ app 25% md sand, moist, non pl, md dense, strg HC odor.	
30.00									
35.00	11 22 20	100.00			0.00	SC		CLAYEY SAND: 5Y5/2 olv gray, vry fn to fn md graded sand w/ app 25% clay, moist, low pl, md dense, sl HC odor.	
40.00	10 12 19	100.00		MC-C230503 MC-C230301	0.00	ML		SILT: 10YR5/4 yllw brown, sl moist, non pl, md dense, some FeOx and root casts.	
45.00	20 33 35	88.00			0.00	ML		SILT: 10YR5/3 brown, silt w/ minor clay, moist, non pl, dense, some FeOx stain.	
50.00	7 15 25	100.00			0.00	SP		SAND: 10YR5/4 yllw brown, vry fn to fn, md graded, subrnd sand, moist, loose.	
55.00	13 16 27	100.00			0.00	SP		SAND: 10YR3/4 dk yllw brown, fn to crs, md graded, subrnd sand, sl moist, loose.	

LOG OF BORING SA38SB04

PROJECT NAME: MCCLELLAN AIR FORCE BASE - OU A							AIR FORCE BASE MCCLELLAN AFB				
PROJECT NUMBER: 21G11500				LOCATION IDENTIFIER: SA38SB04					SHEET: 3 of 4		
Depth (feet)	Blow Counts	Percent Recovery	Sample Interval	Sample ID	OVM Reading	USCS Code	Graphic Log	Lithologic Description		Remarks	
55.00				MC-C230304	0.00	ML					
	7	13 13	100.00					SAND: 10YR3/4 dk yllw brown, fn to crs, md graded subrnd sand, sl moist, loose.			
								SILT: 2.5Y5/3 lt olv brown, silt w/ minor clay, sl moist, ad dense, some FeOx stain.			
60.00											
65.00	26	50	83.00	MC-C230504	0.00	ML		SILT: 2.5Y5/3 lt olv brown, silt w/ minor clay, moist, non pl, dense, some FeOx stain.			
70.00	20	36 50	77.00	MC-C230504	0.00	ML		SILT: 2.5Y5/3 lt olv brown, silt w/ minor clay, moist, non pl, dense, some FeOx stain.			
75.00	19	42 50	77.00	MC-C230505	0.00	ML		SILT: 2.5Y4/4 olv brown, dry, non pl, dense, FeOx stain, some minor caliche.			
80.00	11	16 36	100.00	MC-C230505	0.00	SP		SAND: 10YR5/4 yllw brown, vry fn to fn subrnd sand, sl moist, ad dense, FeOx stain.			
85.00	16	30 50	100.00	MC-C230505	0.00	ML		SILT: 10YR5/3 brown, dry, non pl, dense, FeOx throughout.			

LOG OF BORING SA38SB04

PROJECT NAME: MCCLELLAN AIR FORCE BASE - OU A							AIR FORCE BASE MCCLELLAN AFB		
PROJECT NUMBER: 21G11500				LOCATION IDENTIFIER: SA38SB04				SHEET: 4 of 1	
SI Depth (feet)	Blow Counts	Percent Recovery	Sample Interval	Sample ID	OMI Reading	USCS Code	Graphic Log	Lithologic Description	
88	22 22 23	100 00			0.00	SP			
50 00								SAND: 10YRS/4 yllw brown, vry fn to fn, md graded, subrnd sand, sl moist, loose, FeOx stain.	
18 50 0	83 00			MC-C230503 MC-C230502 MC-C230501	0.00	ML		SILT: 2.5YRS/3 lt olv brown, sl moist, dense, FeOx stain.	
100 00				MC-C230508 MC-C230506					
85 00									
110 00									
115 00									

OU No.: A		Site No.: IC25 SA38		Boring No.: 58006		Geologist: B. Faulkner	
Blow Counts	Time	Gravel	Length	Depth	Sample Number	Sample Time	PILOT HOLE CGI
15							Description/Notes: (LITHOLOGY: Mineral Color, grading angularity, density or consistency, plasticity, odors, staining, GW measurements, drilling notes.)
16							soft, fuel-like odor, homogeneous.
17							
18							
19	13 100%	ML		15 58	9.0	SILT: Olive brown (2.5Y 4/3) nonplastic	
20	22						slow dilatancy, moist, soft, trace clay
21	23 (19.5 - 19.75)	MC-H061201					toward top (19' to 20' along augers), fuel
22	(19.75 - 20.0)	MC-H006004					like odor.
23	(20.0 - 20.25)	MC-H006005					
24	(20.25 - 20.5)	MC-H006006					
25							
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OU No.: A		Site No.: IC23 SA38		Boring No.: SB006		Geologist: B. Faulkner	
Blow Counts	Blow Counts	Gravel	Sand	Sample Number	Sample Time (min)	PID/FID/CGI	Description/Notes: (LITHOLOGY: Munsell Color, grading, angularity, density or consistency, plasticity, odor, staining, GW measurements, drilling notes.)
Max	Min	x 1/2	x 1/2	x 1/2	x 1/2	x 1/2	
35	15						iron oxide stains.
6							
7							
8							
9							
11	100%	ML		1645	23	SILT: Light yellowish brown (2.5Y 6/3)	
28							
40	47	(39.75 - 40.0)	MC-H006007			nonplastic, moist, firm to hard, fuel like odor.	
1		(40.0 - 40.25)	MC-H006008				
		(40.25 - 40.5)	MC-H006009				
2							
17	100%	ML	MC-H006102	1705	5237	Gas sample interval 41.5' - 41.7' bgs.	
3							
4							
12	100%	ML		0759	52	SILT: Light olive brown (2.5Y 5/3)	
23							
45	46					nonplastic, moist, soft, iron oxide stain	
6							
7							
8							
9							
17	100%	SP		0807	34	SAND: Dark grayish brown (2.5Y 4/2) fine grain, trace silt, fuel-like odor.	
10							
50	16	SP				49.5' - 49.75': SILT LAYER.	
1						SAND: Yellowish brown (10YR 5/4) fine grain, trace silt, fuel-like odor.	
2							
3							
4							
10	100%	SP		0816	21	SAND: Brown (10YR 4/3) fine grain, trace medium grain, subrounded to subangular,	
16							
55							

OU No.: A	Site No.: IC 23 SA38	Boring No.: SB006	Geologist: B. Faulkner	
Blow Counts	Sample No.	Sample Time (min)	PI/DID/CGI	Description/Notes:
29				moist, noncemented
30				
31				
32				
33				
34				
35				
36				
37				
38				
39	10 100% SP	0830 12.2	SAND: Dark yellowish brown (10YR 4/4) fine grain with medium grain subrounded to subangular, damp, noncemented.	
40				
41				
42	(Cannister)	MC-H061401	718	Gas sample interval: 61.8 - 62.0
43				
44				
45	15 100% 0855	92	SAND: Dark yellowish brown (10YR 4/6) f. grain, subrounded to subangular,	
46				
47	18		12	SILT: Light olive brown (2.5Y 5/3) nonplastic, no d. lamay, damp, hard.
48	27			
49				
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58				
59	14 100% (70.0 - 70.25)	0905 108	SILT: Light olive brown (2.5Y 5/3) low plasticity, low d. lamay, low to medium	
60			12	toughness, damp, soft to firm, fuel-like iron oxide stain.
61	26 (70.25 - 70.5)	MC-H061202	8848	
62		MC-H061203		
63				
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74				
75	10 100% 0940 14	SILT: Light olive brown (2.5Y 5/3) non plastic moist to damp, firm, fuel-like odor		
76	15			

OU No.: 4 Site No.: IC25 SA38 Boring No.: SB006 Geologist: B. Faulkner

Blow Count	Barite Percent	Barite Hardness	Grading			LEC	Inches	Metres	Sample Number	Sample Time (24 hr)	PID/AD/ CSI	Description/Notes:	
5			Max Size	$\frac{1}{2}$	$\frac{3}{4}$	1/2						(LITHOLOGY: Mineral Color, grading angularity, density or consistency, plasticity, odors, staining, GW measurements, drilling notes.)	
28													
6													
7													
8													
9	14	100%	ML				09 55		417			SILT: Light olive brown (2.5Y 5/3) non-plastic, damp to moist, soft to firm, fuel-like odor, black stains.	
0	28												
1	35												
2													
3													
4													
5	11	100%	ML				11 15		27			SILT: Light olive brown (2.5Y 5/3) non-plastic, damp, soft, mica flakes.	
6	25												
7	33		SM									SAND WITH SILT: Light olive brown (2.5Y 5/3) fine grain, moderately graded, subrounded to subangular, damp, noncemented, mica flakes.	
8													
9	9	100%	ML				11 20		18			SILT: Light olive brown (2.5Y 5/4) low plastic damp, fuel-like odor.	
0	15		SP										
1	27		ML									SAND: Dark yellowish brown (10YR 4/4) fine and medium grain, poorly graded, subrounded mica, noncemented, fuel-like odor, granitic mineralogy.	
2												SILT: (as above) Higher PID readings in silt.	
3													
4	9		ML	9+0	9+25								
5												MC-H061205	
							11 30					SANDY SILT: Light olive brown (2.5Y 5/3) nonplastic, damp.	
												MC-H061204	

OU No.: A		Site No.: IC25 SA38		Boring No.: SB006		Geologist: B. Faulkner	
Blow Counts	Bentonite % Anhydrite Sulfide Sulfate	Gassing		Sample Number	Sample Time (min)	PINDAD/ CSI	Description/Notes: (LITHOLOGY: Mineral Color, grading angularity, density or consistency, plasticity, odors, staining, GW measurements, drilling notes.)
		Max	Min				
Blow Count	Max	Min	Max	Min	Max	Min	Notes
27		ML	SM				SILTY SAND: Light olive brown (2.5 Y 5/3) moderately graded subrounded to subangular damp, fuel-like odor.
				(Canister)	MC-H061403	1145	641 Gas sample interval: 97.6' - 97.8' bgs.
							Total distance drilled: 95.0' bgs.
							Total distance sampled: 97.8' bgs.
							Hole was drilled at an angle of <u>18°</u> off vertical.
							Actual vertical depth drilled = $(\text{auger length}) \cos(18^\circ) = \underline{\underline{90.4' \text{ bgs.}}}$
							Actual vertical depth sampled = $(97.8') \cos(18^\circ) = \underline{\underline{93.0' \text{ bgs.}}}$